

## DEPARTMENT OF DEFENSE WEATHER PROGRAMS

The Department of Defense (DOD) operates a military environmental service system to provide specialized worldwide meteorological, space environmental and oceanographic analysis and prediction services in support of military forces. This system directly supports all phases of military operations, from strategic planning to tactical operations. While the Army and Marine Corps each have a small specialized weather support capability, the Naval Meteorology and Oceanography Command and Air Force Weather are the primary sources of military weather products. The military weather services contribute to the national and international weather observing capability by taking conventional observations on land and at sea where there are no other conventional weather observing capabilities and where the observations are most needed to meet military requirements. In addition, DOD maintains specialized observing capabilities, such as the Defense Meteorological Satellite and Global Weather Intercept Programs, to meet unique military requirements. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.



### UNITED STATES AIR FORCE

#### METEOROLOGICAL SERVICES

The Air Force (AF) functional manager for meteorological and space environmental services is the Director of Weather within the Headquarters United States Air Force, Deputy Chief of Staff for Air and Space Operations (HQ USAF/XOW). The Air Force Director of Weather (AF/XOW) oversees the development and implementation of operational concepts, doctrine, policies, plans, and programs to provide effective environmental information for the AF, Army, and other agencies as directed by the Chief of Staff, United States Air Force (USAF). The AF provides environmental information to DoD Joint operations as directed by the Joint Chiefs of Staff (JCS) under the Unified Action Armed Forces (JCS Publication O-2) document. The AF/XOW interfaces with other military departments, federal agencies, and international organizations concerning coordination, cooperation, standardization, and interoperability of weather services.

Air Force Weather (AFW) Organization. AFW is a Total Force organization, employing the active forces as well as Air Force Reserve (AFR) and Air National Guard (ANG) weather personnel. The active component of AFW has recently completed

reengineering to mirror the three levels of military operations--strategic, theater (operational), and tactical. The Air Force Weather Agency (AFWA) is a field operating agency (FOA) reporting directly to AF/XOW. AFWA serves as Lead Command for AFW, maximizing our nation's air, space and ground combat effectiveness by delivering accurate, relevant, and timely strategic-level terrestrial and space weather information to worldwide customers in addition to fulfilling certain unique mission requirements. The FOA, located at Offutt Air Force Base (AFB), Nebraska, consists of a strategic processing center collocated with a functional management headquarters; two subordinate units, the Air Force Combat Climatology Center (AFCCC) at Asheville, North Carolina, and the Air Force Combat Weather Center (AFCWC) at Hurlburt Field, Florida; and seventeen detachments and operating locations. AFWA creates and maintains the world's most comprehensive weather database of atmospheric forecast, climatological, and space weather products. Additionally, AFWA provides backup support to five national weather centers.

There are eight Operational Weather Squadrons (OWS) that assess weather data and develop theater-level environ-

mental information tailored to overseas theater Combatant Commander and/or Numbered Air Force (NAF) operations (Figure 3-DoD-1). Each OWS is designated as the forecast agency for a specific geographical area of responsibility (AOR) in concert with their associated NAFs or Theater's AOR. Continental United States (CONUS) OWSs are also responsible for CONUS regional weather information. OWSs provide theater-scale, tailored, environmental information to active duty as well as AFR and ANG units. They produce and disseminate terminal forecasts, weather warnings and advisories, planning and execution area forecasts, and other operational products to AF Combat Weather Teams (CWTs) using the OWS Production System Phase II (OPS II). This system provides a capability to integrate strategic-level and indigenous data to automatically and manually generate weather forecast products, and supports the dissemination of these products to CWTs and other users. Recent improvements include automating pilot briefing forms, and enhancing operations in the classified environment.

CWTs, located at base and post level, take and disseminate local observations and provide mission-tailored

# AF Weather OWS AORs

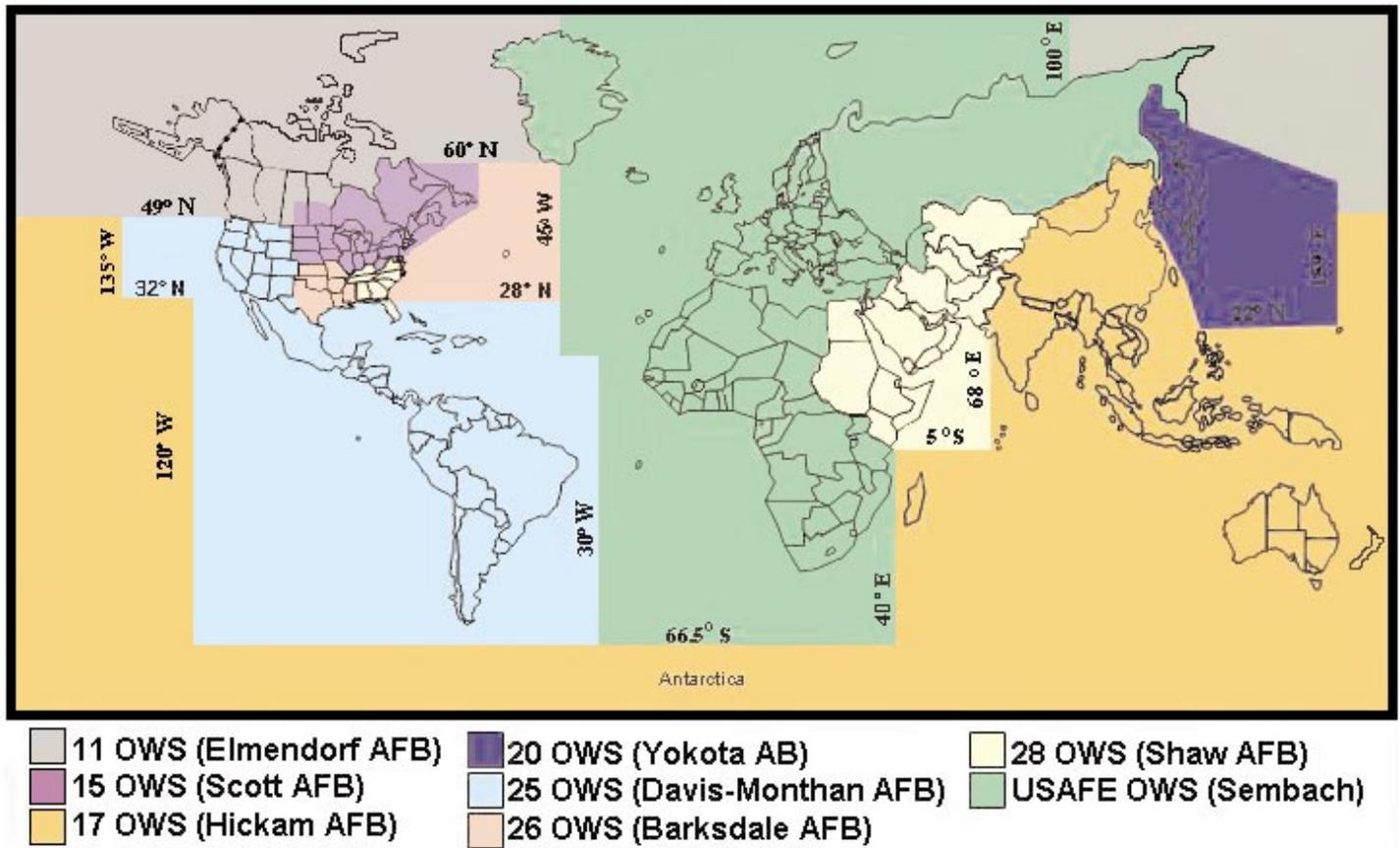


Figure 3-DOD-1. Areas of Responsibility for Air Force Weather's Operational Weather Squadrons.

forecasts and briefings at the tactical level based on centrally produced guidance. The CWTs perform the "eyes forward" mission of the OWSs. Using the New Tactical Forecast System (NTFS) as the primary tool, the CWTs provide tailored mission forecasts to the operator. These forecasts include tactical decision aids and target scene simulations to enhance mission performance on the battlefield. AFW continues to progress on integrating weather information directly from CWTs and OWSs into command and control systems. In the deployed environment, the CWTs bring experienced weather personnel to support battlefield operations. To do this, they deploy with the NTFS, the newly acquired hand-held Kestral observing system at very sparse locations, the TMQ-53 semi-automated observing

system for the less mobile sites, and, in some cases, tactical weather radars.

In addition to the active duty force, approximately 82 weather personnel serve as AFR individual mobilization augmentees assigned to various active AFW units at all levels. They typically train one day each month and for an additional two weeks each year.

The ANG program consists of two distinct functions. The traditional program consists of 33 weather flights, ranging in size from 13 to 25 personnel. The flights meet monthly to train for their wartime missions and provide weather information to Army National Guard and United States Army Reserve units as well as ANG flying units. The ANG operates the Weather Readiness Training Center at Camp Blanding in Starke, Florida, to provide Army tactical skills training that is not

available elsewhere in the Air Force. The ANG is also responsible for peacetime weather operations at locations where the ANG is responsible for airfield support.

AFW is currently engaged in reengineering the AFR and ANG weather forces to more closely align operations with active duty forces. Total Force AFW personnel enhance the unique global capability of ground and aerospace military operations, while indirectly assisting civil aviation by providing flight weather briefings, air/ground radio services, and tailored observations, forecasts, watches, and warnings for military operations.

## AFW Five Core Processes.

To fulfill its global mission of providing timely, accurate, and relevant weather information, AFW maintains and continually improves on its five

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core processes: data collection, analysis, forecasting, product tailoring, and dissemination. The following paragraphs provide more information on each of these areas.

Weather Data Collection integrates the spectrum of remote and fixed sensors into a single meteorological sensing and instrumentation approach for battlefield and in-garrison operations. Data collection in the space environment is discussed later, in the Space Environmental Services section. AFW personnel take observations essential for effective military operations and for weather analysis and forecasting. Weather personnel at both AF and Army locations (fixed and tactical) make observations available to local users and transmit them to military and civil locations throughout the world. Upper air observations provide vital input to numerical weather analysis and prediction. United States and foreign rawinsonde reports are primary sources and are supplemented with military and civilian pilot reports. The Observing System 21st Century (OS-21) program will provide a much-needed, state-of-the-art, life-cycle replacement for Air Force observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. The manual configuration is intended for tactical operations and continues the improvements begun under the Manual Observing System and Tactical Meteorological Observing System Modification programs. AFW has begun fielding the fixed base automated observing system and will continue to do so over the next 2-3 years. The remaining configurations will be upgraded or replaced after the fielding of the fixed base automated systems nears completion.

Weather radar data is a principal source of information needed to produce severe weather warnings. Within the CONUS, AFW uses the WSR-88D. DoD, the National Oceanic and

Atmospheric Administration (NOAA), and the Federal Aviation Administration (FAA) operate and maintain the WSR-88Ds within CONUS, and the AF operates and maintains the overseas WSR-88Ds. Newly acquired Tactical Weather Radars (TWR), which will provide a weather radar capability for worldwide military contingency operations, will replace already existing radars at deployed locations and at select fixed locations overseas.

The Defense Meteorological Satellite Program (DMSP), which provides a large volume of cloud, upper air, and space environmental data, is a vital source of global weather data used to support combat operations. On-board sensors provide AFWA and the Navy's Fleet Numerical Meteorology and Oceanography Center with visible, infrared, and microwave imagery of the entire globe, temperature and moisture sounding data, electrically charged particle fluxes, and other specialized space environment data. DMSP also supplies direct, real-time readout of regional imagery and mission-sensor data to DoD land-based and shipboard terminals located worldwide.

The present DMSP satellite series (Block 5D-2) uses the Operational Linescan System to provide visible imagery to distinguish between clouds, ground, snow, and water. The DMSP also flies microwave temperature and moisture sounders (SSM/T and SSM/T-2). Processing algorithms convert the sensed data into vertical temperature, moisture, and height profiles of the atmosphere, providing key data for numerical analysis and forecasting. The microwave imager (SSM/I) observes rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data. The space environment on the topside of the ionosphere is measured in situ by the topside plasma monitor (SSIES), a magnetometer (SSM), and

the precipitating particle monitor (SSJ), providing inputs to space weather models. The Block 5D-3 spacecraft are scheduled to begin service in 2003 with the launch of DMSP Flight 16. The new spacecraft will add several new capabilities: enhanced microwave imaging and atmospheric temperature/moisture sounding through the Special Sensor Microwave Imager/Sounder (SSMIS); new auroral boundary and electron density measuring capability through the Special Sensor Ultraviolet Spectrographic Imager (SSUSI); and profiles of upper-atmospheric temperature, electron content, and species densities through the Special Sensor Ultraviolet Limb Imager (SSULI).

AFW continues to participate in the refinement of requirements for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS will replace the existing DMSP and NOAA polar-orbiting satellite systems beginning in approximately 2009 and is a joint DoD, DoC, and National Aeronautics and Space Administration (NASA) program. A new ground terminal system will also provide a direct readout capability for tactical users similar to that of the DMSP. AFW also expects to gain operational experience as well as benefit from the risk reduction planned with the NPOESS Preparatory Program planned for launch in CY 2005.

In addition to DMSP polar-orbiting data, AFWA receives stored data from the DoC's Polar-orbiting Operational Environmental Satellite constellation and real-time high-resolution data from the DoC's Geostationary Operational Environmental Satellite (GOES) East and West, the European Union's Meteosat-5, Meteosat-6, and Meteosat-7 geostationary satellites, and Japan's Geostationary Meteorological Satellite-5. AFWA receives data files from India's INSAT-1D geostationary satellite, as well as NASA's

Tropical Rainfall Measuring Mission (TRMM), NASA's scatterometer mission, QuikSCAT, and NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), via the Shared Processing Program.

To receive real-time visible, infrared, and microwave imagery and other non-imagery weather data from both polar-orbiting and geostationary satellites, the AFW implemented the Joint MET-SAT Imagery, Software, and Terminals (JMIST) concept. JMIST leverages network and satellite communications, direct read-out terminals, and client applications.



The Air Force Reserve Command's 53rd Weather Reconnaissance Squadron (53 WRS), also known as the "Hurricane Hunters," provides another means of collecting vital meteorological data, especially in and around tropical cyclones. Their specially equipped WC-130 aircraft collect temperature, moisture, wind, pressure, and visually observed information at the aircraft location as well as vertical profiles of the atmosphere collected by dropsondes. They penetrate the eyes of tropical cyclones to provide the National Hurricane Center a very accurate center fix location as well as other meteorological parameters, including sea level pressure. In addition to the tropical cyclone reconnaissance mission, the 53 WRS collects meteorological information to improve wintertime West Coast forecasts and to support scientific field programs when possible. For more information, see their web site at <http://www.hurricane-hunters.com/>.

Analysis and Forecasting. AFWA is the AF's strategic production center for weather analyses and forecasts while the OWSs are the theater-scale production centers for AF and Army operations. AFWA uses networked computer systems and an interactive graphics and imagery system to implement a "build-and-apply" concept. Worldwide conventional weather data are relayed to AFWA and combined with civil and military meteorological satellite data to construct a real-time, integrated environmental database. Computer programs further process the data to construct models of the atmosphere and forecast its future behavior. Manual tailoring of the data is critical for application to the specific needs of the warfighters. The interaction between forecaster and machine is accomplished using the Satellite Data Handling System (SDHS) at the strategic center; the OWS Production System (OPS-II) at the operational level; and the NTFS at the tactical level.

AFWA has organized forecast operations to achieve greater flexibility and focus on primary missions. Forecasts are generated in the agency's Global Weather Center Division, which consists of four production branches: Special Support Operations, Space Weather, National Intelligence Community (NIC) Weather, and Meteorological Satellite Applications.

The Special Support Operations Branch (SSOB) acts as an OWS for Special Operations Forces (SOF) and provides worldwide mission-tailored forecasting to Joint SOF operations. The branch acts as a clearinghouse for unique data requests from the SOF community; provides tailored meteorological information for end-to-end special operations planning at US Special Operations Command, the component level; and for theater special operations commands. The SSOB is continually involved in worldwide military operations to include

Operations ENDURING FREEDOM and IRAQI FREEDOM. They provide a myriad of products ranging from air refueling forecasts, to detailed mission control forecasts, to weather impacts for SOF operations, and distribute this information via secure media. Additionally, the SSOB includes the American Forces Network Weather Center which provides worldwide, broadcast-quality public weather services and planning forecasts through the American Forces Radio and Television Service to over 800,000 DoD and Department of State personnel and family members stationed overseas.

The Space Weather Operations Center (Space WOC) provides worldwide general and tailored analyses, forecasts, advisories, and warnings of space weather phenomena that affect military operations and National Intelligence Community activities. The Space WOC supports all DoD Services using space weather measurements from an integrated, global network of ground- and space-based sensors. Data sharing and forecast coordination exists between the NOAA Space Environment Center (SEC) in Boulder, Colorado and the Space WOC and results in a synergistic capability to reach both military and civilian operators. Due to an increasing dependence on space-based systems such as precision-guided munitions, satellite communications, and modern guidance and radar systems, space environmental impacts are a key and growing field critical to military operations. The reliance on the Global Positioning Systems (GPS) and its vulnerability to ionospheric storms compel military planners and commanders to apply an awareness of space environmental information to all phases of military operations. This was true in Operations ENDURING FREEDOM and NOBLE EAGLE; it is true in routine daily operations as well.

The National Intelligence Community Weather Branch provides

weather information that includes detailed global cloud analyses and forecasts to the intelligence community. The branch employs the NIC Weather Operations Cell that provides worldwide mission-tailored planning and execution forecasts for National Intelligence Community agencies at security levels up to Top Secret/Sensitive Compartmented Information (TS/SCI). The branch also serves as the focal point for AFWA Special Access Program (SAP) requirements; ensures the National Intelligence Community and other SCI and SAP meteorological requirements are integrated into AFWA programs; monitors and evaluates accuracy and timeliness of centralized weather services to the National Intelligence Community; and interfaces with the DoD and National Intelligence Community regarding weather services and exploitation of weather information.

The Meteorological Satellite (METSAT) Applications Branch provides operational imagery analyses production, technique development, technology insertion, and product improvement. The branch produces rapid response, tailored METSAT imagery and evaluation for DoD contingency operations and generates automated METSAT imagery products for web-based distribution to DoD customers. The branch tracks and classifies tropical cyclones for the DoD Joint Typhoon Warning Center (JTWC) and the DoC National Hurricane Center; serves as the DoD focal point for volcanic ash plume detection, advisories, and trajectory forecasts; and provides hot back up for both JTWC satellite operations and the DoC's Washington Volcanic Ash Advisory Center. The METSAT Applications Branch produces worldwide snow and ice cover analyses to update and refine the Snow Depth database and also provides tailored snow depth and dust event analyses in contingency areas. During

Operation IRAQI FREEDOM, branch imagery specialists provided high-resolution analyses of oil fire initiation points for smoke plume dispersion forecast model products. These smoke plumes impacted both air and land operations. Advance notice allowed mission planners to modify operations to maximize mission effectiveness. The branch also develops new capabilities to display and visualize satellite imagery on workstations and infuses state-of-the-art techniques into improved imagery analysis ensuring high quality customer products.

The recently completed Global Theater Weather Analysis and Prediction System (GTWAPS) program has improved interaction of the strategic, OWS theater-level, and CWT tactical-level forecasting systems. The key software component of the GTWAPS program is a theater analysis and forecast model, Mesoscale Model version 5 (MM5), which provides fine-scale forecast data with improved accuracy. During Operation ENDURING FREEDOM, AFWA initiated various model window locations and resolutions as mission requirements dictated. The highly responsive nature of the MM5 and the way AFWA employs it, permitted new contingency windows to be operational within hours. Advancements in cloud modeling have enabled GTWAPS to produce high-resolution products that became a mainstay of weather data during Operation ENDURING FREEDOM. Used by Predator Unmanned Aerial Vehicle (UAV), Global Hawk UAV, and space-based reconnaissance operators, these products allowed decision-makers to choose the most effective reconnaissance platform to maximize mission effectiveness. MM5 is routinely provided by AFWA to the NOAA National Centers for Environmental Prediction (NCEP), where it is a backup to their ETA model.

On-going modernization initiatives

at AFWA include the Space Weather Analysis and Forecasting System (SWAFS) and the Weather Data Analysis (WDA) program. SWAFS will integrate additional space weather data sources and execute next-generation space weather models for DoD and National Intelligence Community operations. WDA will continue the modernization of the AFWA as the strategic center component of the Air Force Weather Weapon System (AFWWS). The reengineered AFWA will provide component-based and standards-compliant hardware, software tools, a central data cloud, and a classified processing environment to modernize the AFWWS communications and data processing infrastructure. WDA provides a significant increase in the database capacity and capability by standing up Joint DoD-approved METOC database segments that will begin an era of Common Operating Environment compliance and interoperability among data sharers.

OWSs provide theater-scale battlespace forecasts; drop zone, range, and aerial refueling track forecasts; fine-scale target forecasts; and airfield forecasts and warnings for AF and Army installations within their AOR. Their primary tool is the OWS Production System, Phase II (OPS-II), which ingests data and strategic center information and creates and disseminates theater-scale products.

Product Tailoring/Warfighter Applications. Progressive focusing and tailoring of weather information is the heart of the AFW organization, leading to individual mission-specific information provided at the CWT level. An example of specific mission tailoring performed for an emerging system still in testing is the Global Hawk high-altitude reconnaissance system and the turbulence forecasts provided by the weather personnel.

The Forecasting System 21st Century (FS-21) program is the vehicle

for providing necessary computer hardware and software throughout all levels of AFW (AFWA, OWSs, and CWTs). The OPS-II is the backbone of the OWS production system. This hybrid system of databases, servers, and workstations, provides the computer hardware and software necessary for OWSs to produce and disseminate forecast products to CWTs.

The New Tactical Forecast System (N-TFS) provides garrison and deployed CWT personnel with the meteorological tools to manipulate and disseminate graphical and alphanumeric products (satellite imagery, graphical forecast products, weather forecasts, advisories, briefings, observations, etc.) to Army and AF operational, command and control, and support forces worldwide. N-TFS provides weather personnel the ability to use the same system in "peace and war," providing a "first in" and sustainment weather forecast capability to combat weather units worldwide. Additionally, N-TFS ingests data from AF observing systems and observations from indigenous sources, which then are forwarded to OWSs/AFWA for further dissemination and incorporation into the centrally produced models. Data from the N-TFS, combined with satellite imagery from the STT, provide the essential capability required for deployed weather units to meet operational requirements. AFW is currently working toward a single workstation that integrates both the Army's Integrated Meteorological System (IMETS), the AF's NTFS, and provides the interface capability for command and control systems.

Tactical Decision Aids (TDAs) provide warfighters an automated way to "visualize" environmental impacts on operations. These tools, which continue to be integrated into command and control systems and mission planning systems, include Target Acquisition Weapon Software (TAWS) (Figure 3-DOD-2), Night Vision

Goggles Operations Weather Software (NOWS), InfraRed Target Scene Simulation (IRTSS), and Joint Environmental Exploitation Segment (JEES). All are modular programs developed by the Air Force Research Laboratory (AFRL) with additional assistance from the Navy's Space and Naval Warfare Systems Command, the Navy Research Laboratory and the Army Research Laboratory. TAWS provides a mission-planning tool to combine platform, weapon, target, background, and weather impacts to depict three-dimensional target acquisition and lock-on range versus time. NOWS (soon to be integrated into TAWS) provides environmental impacts on night vision goggles used

TAWS modules to automatically generate mission impact forecasts for large scale planning efforts such as Air Tasking Order preparation. JEES, TAWS, NOWS, and IRTSS integrate environmental impacts into the Mission Execution Forecast for Command and Control and Mission Planning Systems from zero to 48 hours prior to mission execution. The TDA program continues to add weapons systems, targets, and other features at the request of operational customers from all three services. During Operation ENDURING FREEDOM, the WarWeather program provided additional targets requested specifically for application with TAWS and NOWS in operations.

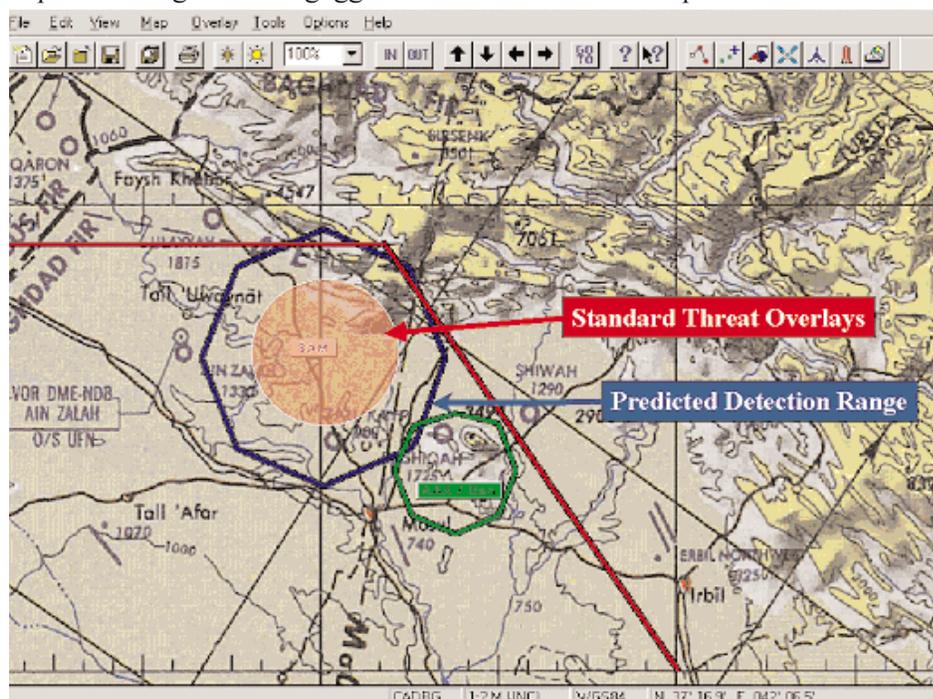


Figure 3-DOD-2. Tactical Acquisition Weapon Software (TAWS) integrate meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution.

by aircrews, naval, and ground forces to execute nighttime operations, including search and rescue. IRTSS uses detailed terrain information and multi-spectral imagery with TAWS processing to generate forecast target scene images for mission rehearsal. JEES uses environmental data with

The space weather branch produces tailored forecasts to model space weather impact to High Frequency (HF) and Ultra-HF SATCOM communications. These products leverage space weather expertise at AFWA for all theaters. A point-to-point communication forecast can be tailored to pro-

vide users the optimal HF frequencies to use between two locations. Also, signal fades due to space weather on UHF SATCOM links provide valuable planning information to command and control.

**Dissemination.** AFW dissemination employs a variety of media to meet the needs of its worldwide customer base. High-speed communications between large DoD and civilian processing centers facilitate sharing of data, high-resolution satellite imagery, and output from numerical weather prediction models. Additional circuits provide a subset of these data to the OWS facilities.

Forecaster-developed products and gridded data sets are distributed from AFWA via the Communications Front-End Processor to base and post weather stations worldwide using dedicated circuits and the Internet. Alphanumeric data including surface, upper-air, aircraft reports, and space weather are also collected and distributed via the AWN, VSAT, and the DoD's Non-Secure Internet Protocol Router Network (NIPRNET).

The AWN is a global communications network used for collecting and distributing alphanumeric terrestrial and space weather data throughout the AF Weather Weapon System; Navy and Army weather systems; and federal and foreign meteorological, space, and aviation centers and consists of sophisticated data collection, message creation, and dissemination software.

DoD data is also received from DoD-operated HF radio receiver sites strategically positioned around the globe to intercept weather broadcasts. These broadcasts originate from nations that do not routinely make data available through World Meteorological Organization channels.

AFWA receives alphanumeric weather data, parses them according to data type, eliminates duplicate reports from different sources, and creates specially tailored bulletins. Some of these

bulletins are sent to the large processing centers to provide the input data for global, regional, and fine-scale forecast models. Other bulletins are redistributed to end-users over dedicated circuits, NIPRNET, and satellite broadcast facilities.

AFW operates a website on the NIPRNET known as the Joint Air Force-Army Weather Information Network (JAAWIN). JAAWIN provides worldwide access to numerical model forecast graphics, satellite imagery, forecaster-in-the-loop graphics, and text bulletins. Additional products are available to classified customers via the JAAWIN-Secret (JAAWIN-S) and JAAWIN-Sensitive Compartmented Information (JAAWIN-SCI) capabilities.

An additional means of making tailored weather information available to DoD customers includes the Joint Weather Impacts System (JWIS). JWIS provides a link to weather information from both AF and Navy sources for use by command and control systems and applications. AFW successfully demonstrated JWIS during Joint Expeditionary Force Experiment 2000, and integrated an initial capability into the Combined Air Operations Center-Experimental in 2001.

Finally, AFWA continued to enhance its presence on the AF Portal, an initial "one-stop gateway" capability established in 2001 to provide weather and other information to any AF user or activity. AFWA will continue expanding this capability in FY 2004.

**Unique Requirements.** A special aspect of the military weather mission is the need to provide decision assistance to commanders and resource managers as well as operational units. To fulfill this requirement, designated AFW personnel serve as part of the staff of operational AF, Army, and joint force units. In this capacity, AFW personnel identify all weather-sensitive areas of the operation, monitor the

weather service provided in these areas, and provide expert advice to mitigate weather impacts on either training or combat operations. Products and data are tailored to the needs of weapon systems being developed or used; command and control systems; Army firing units; research, development and evaluation; testing, training and deployment of military forces; and contingency operations. This effort helps ensure that AF, Army, and joint force units fulfill their missions regardless of the weather and results in efficient use of weather resources by gearing them to specific requirements.

Army weather requirements are completely integrated into the AF's overall mission concept. The Army trains and educates AF personnel on Army organizations, concepts of operations, and the weather sensitivities of Army operations and equipment. AFW units are aligned and integrated with the Army intelligence organization. Weather products are tailored to be pertinent to and directly usable by Army personnel and are integrated into Army communications systems. Mobile and fixed meteorological equipment is programmed by the AF. In a tactical environment, weather personnel serve with echelon-above-corps, corps, divisions, separate brigades, regiments, aviation brigades, armored cavalry regiments, ranger regiments, and special forces groups (as well as subordinate battalions deployed at forward operating bases). The AF provides observers to all command levels identified above. The Army Forward Area Limited Observing Program and the Army artillery meteorology program augment the AF observations in the tactical environment.

The AF provides meteorological and space weather products to the Nation's space and missile programs including a wide range of weather observing services at the AF Eastern Range and the Kennedy Space Center. The AF pro-

vides tailored forecasting for NASA's manned and unmanned launches and for commercial launches from the Kennedy Space Center. The AF also provides specialized meteorological information to the AF Western Range at Vandenberg AFB, California, and the Pacific Missile Range, which includes Point Mugu and San Nicholas Island, California, and Barking Sands, Hawaii. In addition, the AF provides environmental information to the White Sands Missile Range, New Mexico, the Kwajalein Missile Range, Republic of the Marshall Islands, and other DoD research and test facilities.

The AF furnishes environmental information to DoD Special Strategic Programs, the President, Secretary of Defense, the National Military Command System, and the National Security Agency. Tailored environmental products are disseminated to these customers worldwide.

The AF also provides agrometeorological output to the United States Department of Agriculture's Foreign Agricultural Service and other similar customers. The output provided includes diagnostic soil hydrology and other meteorological output pertinent to crop growth and yield estimation as well as trafficability and rudimentary flooding estimations.

AFCCC provides climatic data and specialized products to the AF, Army, and other government agencies. Typical climatic information satisfies requirements for assessments of natural environmental effects on military plans, weapon systems, facilities, and intelligence activities. AFCCC collects, quality assures, and applies worldwide surface and upper air observations, satellite derived soundings, numerical model output such as global gridded surface and upper air model data, a global three-

dimensional cloud analysis (worldwide merged cloud analysis), a global analysis of snow cover, and other specialized environmental data sets. AFCCC produces standard climatic summaries of meteorological phenomena for points worldwide. Examples of these standard products include the Operational Climatic Data Summary and the Wind Stratified Conditional Climatology. Analysts are also available to produce tailored products to meet specific customer requirements. AFCCC employs the Atmospheric Slant Path Analysis Model to produce vertical profiles for any point around the globe for any time since 1987. Modeled climatologies are produced using the Advanced Climate Modeling and Environmental Simulations model. AFCCC is collocated with the National Climatic Data Center to facilitate cooperation and data exchange.



Figure 3-DOD-3. Solar optical and radio telescopes at Ramey, Puerto Rico and Learmonth, Australia (lower left).

AF/XOW is the DoD Modeling and Simulation Executive Agent for the Air and Space Natural Environment. The director executes his responsibilities through OL-M, AFWA, located in Asheville, North Carolina. The Executive Agent is responsible for ensuring modeling and simulation developers and users have the tools, infrastructure, and databases necessary to represent the air and space environment rapidly, thoroughly, accurately, and consistently in a manner that promotes cost-effectiveness, ready access, interoperability, re-use, and confidence. OL-M sponsors research and development and fields technology at AFCCC--the designated operational center providing tailored atmospheric data for modeling and simulation. OL-M also sponsors ongoing research in cooperation with the National Geophysical Data Center and the Defense Modeling and Simulation Office (DMSO) to develop a similar capability to provide tailored, on-demand representations of the space environment.

### SPACE ENVIRONMENTAL SERVICES

AFWA is the DoD focal point for space environmental information and participates with NOAA in the operation of its SEC. Many DoD systems are affected by space weather phenomena occurring in the near-Earth environment. Space weather impacts fall in three general categories: electromagnetic radiation, high-energy charged particles, and electrically charged particle clouds. AFWA provides a suite of automated and manually tailored space weather products to the customers susceptible to these impacts.

Sources of Space Environmental Information. A variety of ground- and space-based space weather data is available to forecasters providing information for space weather operations.

AFWA operates a network of solar

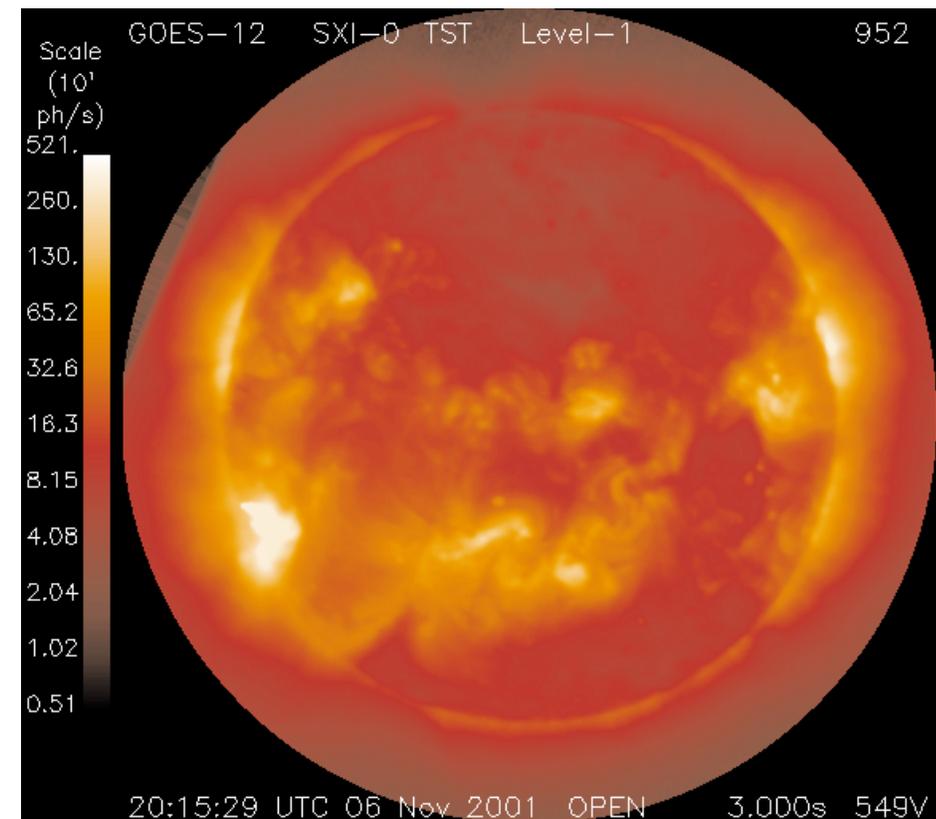


Figure 3-DOD-4. SXI imagery (visualization courtesy of NOAA).

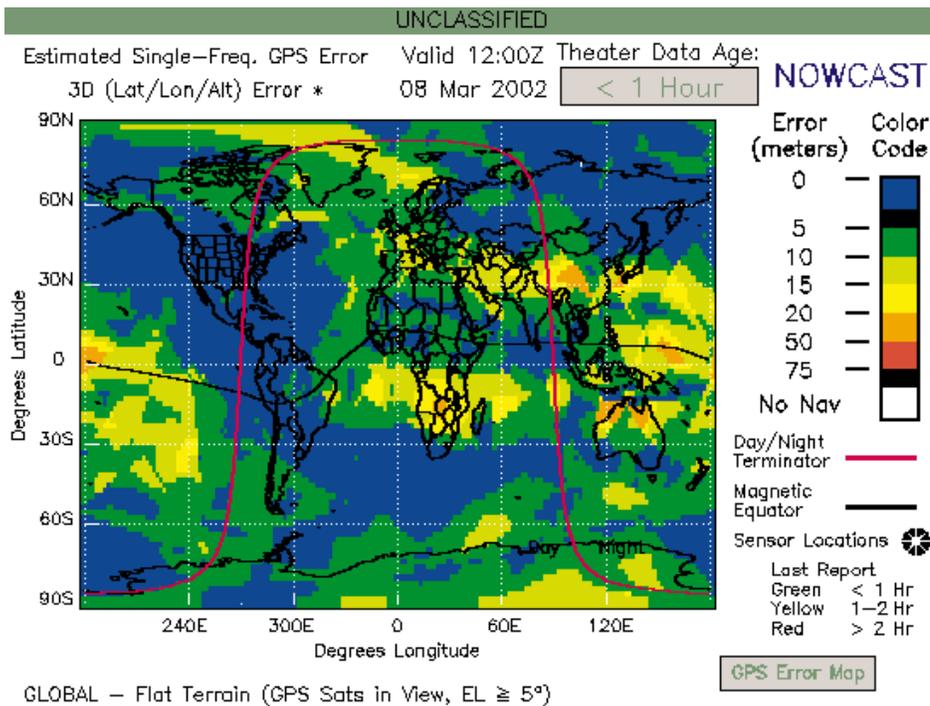
optical and radio telescopes at Sagamore Hill, Massachusetts; Holloman AFB, New Mexico; Palehua, Hawaii; San Vito, Italy; and Learmonth, Australia. These systems provide observations of solar phenomena at optical and radio wavelengths (Figure 3-DoD-3).

A worldwide (primarily Northern Hemisphere) network of ground-based ionosondes and other sensors provide ionospheric data. AFW manages 16 automated Digital Ionospheric Sounding Systems (DISS) to provide measurements of disturbances in the ionosphere. The Jet Propulsion Laboratory also operates a complementary global network of sensors providing ionospheric data and the United States Geological Survey (USGS) operates a network of magnetometers located primarily in the Northern Hemisphere. The USGS data provides indirect measurements of the strength of ionospheric and magnetospheric electric currents, which create their own magnetic field superimposed upon the Earth's magnetic field.

AFWA receives these data from the SEC.

The GOES meteorological satellites provide real-time solar X-ray, electrically charged energetic particle, and geomagnetic data, made available through the SEC. DMSP, NOAA, and other DoD geostationary satellites provide additional energetic electrically charged particle data in low-Earth and geosynchronous orbits. Additionally, AFW leverages space-based data from NASA and other agencies. For example, NASA's Advanced Composition Explorer satellite provides real-time solar wind data, critical for forecasting geomagnetic disturbances.

A number of additional sensors or improvements to existing space weather sensors are planned. The Solar X-Ray Imager (SXI) recently became operational on GOES-12. The SXI monitors solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum (Figure 3-DoD-4) and provides near real-time display at AFWA and the Space Environment Center. The first



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Figure 3-DOD-5. Single-Frequency GPS Receiver Error Map (visualized by HQ AFWA)

Solar Radio Burst Locator underwent Field Demonstration Evaluation in early CY 2003, to provide radio wave measurements of the sun while also mapping certain solar phenomena blocked from optical view by cloud cover. AFWA has additional improvements scheduled for the optical telescopes as well as for the ionospheric sensors.

AFWA uses a suite of space weather models to specify current solar or global characteristics of space weather where observations are not available and to assist in forecasting future conditions. These models use available observations and include both climatology-based and physics-based algorithms. Some of the products created with these models include the Single-Frequency GPS Receiver Error maps (Figure 3-DoD-5), UHF Satellite Communication Scintillation maps (Figure 3-DoD-6), HF Illumination maps (Figure 3-DoD-7), and Radar Auroral Clutter maps. These products help warfighters determine where space weather is impacting their mission.

More detailed descriptions of both the available observations and current models are available in Chapter 2 of the *National Space Weather Program Implementation Plan*, Second Edition, available from the Office of the Federal Coordinator for Meteorology.

Mainstreaming Space. AFW continues its effort to "mainstream" space weather for both providers and users. DoD's increasing reliance on space weather-affected systems, continuing expansion of operations into space, and the AF's designation as executive agent for space indicates space weather will become increasingly important. AFW will treat space weather initiatives the same as it does terrestrial weather initiatives. Once fully mainstreamed, the spectrum of weather information users should think of space weather as quickly as they do terrestrial weather. The AFW goal is to create a seamless, real-time depiction of the entire natural environment from the mud to the sun by planning, programming, and budgeting for space weather initiatives following the National Space Weather Program and

National Security Space Architect's space weather architecture. AFW is taking steps to standardize space weather operations, improve space weather training for both providers and users, integrate dissemination channels for both space and terrestrial weather, and improve customer interaction. To improve interaction, AFW in conjunction with the AF Flight Standards Agency has modified the flight weather briefing form to include space weather effects on navigation and communication and establishing a space weather "pilot report" process to obtain feedback to identify, quantify, and archive space weather impacts.

### RESEARCH INITIATIVES

The overarching objective of the AF meteorological and space environmental research and development (R&D) program is to provide capability designers, operational weather personnel, and weather information users with the technology and tools to gain and maintain the advantage over a potential adversary. Documented R&D requirements in the atmospheric sciences are articulated in the AFW Mission Support Plan and in the Mission Area Plans of the AF major commands. Space environment R&D is targeted to meet the DoD's space weather requirements as summarized in the National Security Space Architect's Space Weather Architecture Study, as well as the National Space Weather Program Implementation Plan, Second Edition. AFW also strives toward improvements through cooperative research and development agreements with for-profit companies.

In meteorological R&D, the AF is improving cloud depiction and forecasting (CDF) techniques by doubling the resolution, integrating geosynchronous METSATS into the cloud analysis, using a new cloud interpretation scheme, and blending numerical weather prediction with forecast cloud advection techniques. The AF has transitioned key advances in tactical

decision aids into operations, permitting improved forecasting of electro-optical system performance and generation of cloud and target scene visualizations for training, system development, and mission rehearsal. In addition to internal efforts, AFW will continue to rely on collaboration and leveraging of efforts with other federal meteorological agencies, research labs, and universities to further improve CDF system performance and meet other research needs.

Mesoscale Modeling for Air Force and Army Operations. Efforts have continued for combining the MM5 and Land Surface Model (LSM) for use by AF and Army operations. Recent research paid off with the development of a coupled MM5-Land Surface Model (LSM) capability. The LSM analyzes the current state of the land surface to provide information to both DoD and civilian agencies and, through coupling with MM5, will improve forecasting performance in the low levels of the atmosphere. This allows AFW to provide better forecasts for low-level aircraft operations, the dispersion of aerosol contaminants, and the employment of precision-guided munitions. It also allows for assessment of trafficability for ground forces. The advances achieved in the LSM are also being carried over into Weather Research and Forecast (WRF) model development, another area of AFWA participation in research. AFWA is closely collaborating with the National Center for Atmospheric Research (NCAR), NOAA's NCEP, NOAA's Forecast Systems Laboratory (FSL), the University of Oklahoma's Center for the Analysis and Prediction of Storms, and others in WRF development. WRF is the next generation community model expected to replace MM5, and AFWA is benefiting by leveraging the efforts of 537 registered users developing the model. AFWA is preparing to fully implement WRF operationally in the 2004 to 2005 time-

frame and in 2004 will continue with sponsorship and funding of development at NCAR and FSL, test and evaluation of real-time runs of the WRF prototype, and will lead the LSM Working Group while participating in others.

Another example of how AFWA has benefited from its R&D approach of strategic partnering is in the data assimilation arena. AFWA's partnership with NCAR has resulted in an advanced 3-Dimensional VARiational (3D-VAR) data assimilation for the MM5 modeling system. The 3D-VAR system will replace AFWA's current Mesoscale Data Assimilation System and Multi-Variate Optimum Interpolation operational data assimilation system.

Atmospheric Optical Turbulence. Electro-optical (EO) systems are adversely affected by optical distortions caused by thermal or refractive turbulence. As the sophistication of current and next generation military systems grows, the requirement for more detailed knowledge of fine scale

(meters or less) atmospheric behavior also grows. The Airborne Laser (ABL) program is one such capability whose performance is highly dependent on the variations of the meteorological conditions that produce turbulence. The AF program in atmospheric optical turbulence measurements and modeling seeks to address these needs. Researchers used a balloon-borne turbulence sensor mated to a standard radiosonde to obtain measurements, producing data and empirical models that are the basis for ABL system specification. Balloon-borne measurements were made in conjunction with airborne stellar scintillometer measurements to understand the relation between atmospheric structure and path-integrated optical effects. The turbulent scalar spectrum was also sampled using balloon-borne high-bandwidth sensors. As part of an international program, aircraft measurements of temperature and velocity turbulence have been made in different locales worldwide. Horizontal measurements by the aircraft augment the

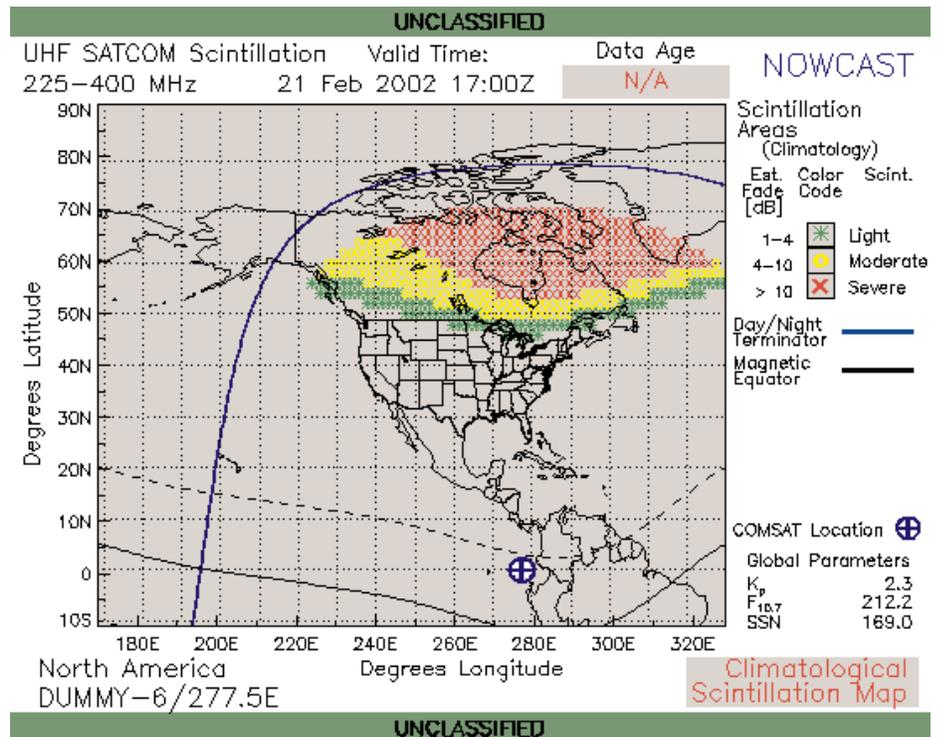


Figure 3-DOD-6. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

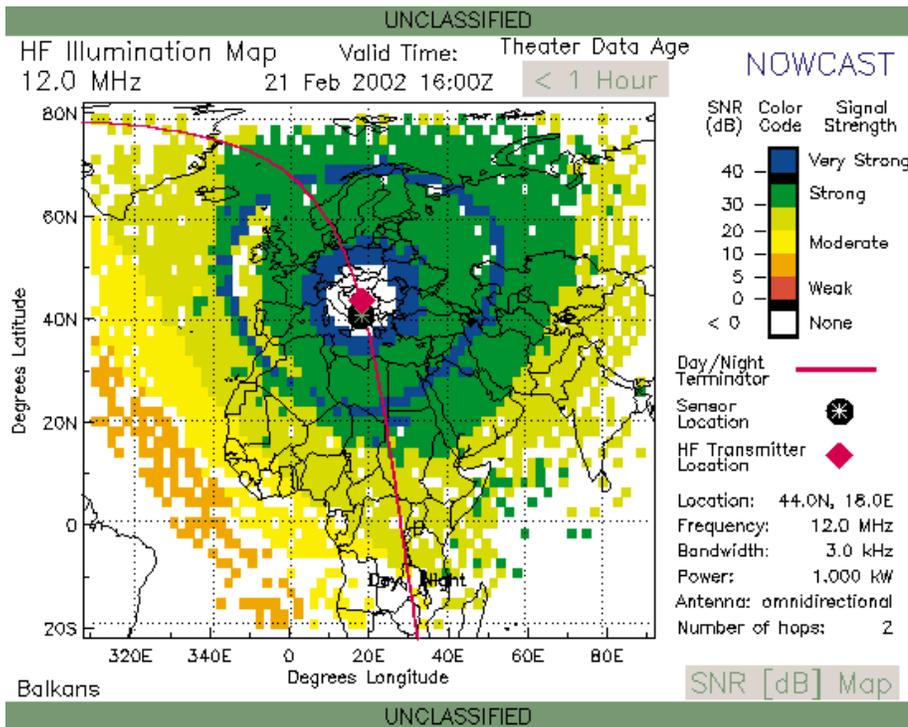


Figure 3-DOD-7. HF Illumination Map (visualized by HQ AFWA).

vertical profiling by balloons to assist in the development of the detailed knowledge required by new EO systems.

Atmospheric Optical Opacity. Air- and space-borne reconnaissance systems are adversely affected by optical distortions caused by clouds, fog, haze, and other airborne particles. As the sophistication of current and next generation military systems grows, the requirement for more detailed knowledge of smaller scale (meters) atmospheric behavior also grows. The AF's CDFS-II program seeks to address these needs.

Radar Analysis using Digital Terrain Elevation Data (DTED), MM5 data, and Advanced Propagation Model (APM) Prediction Software (RADMAPS). Through the University Partnering for Operational Support (UPOS) program, Johns Hopkins University Applied Physics Laboratory (JHUAPL) has developed RADMAPS, an application to assess and forecast anomalous propagation for ground based, airborne, and sea based radars. RADMAPS uses DTED from the National Imaging and Mapping

Agency along with a newly developed and unique MM5 capability to forecast radar refractivity in the lower atmosphere and the APM (a model developed by Space and Naval Warfare Systems Command to predict atmospheric and terrain effects on radar performance).

United States Weather Research Program (USWRP). AFW first entered into discussions with USWRP in 2001 to explore expanded participation in the program. USWRP's mission is to accelerate forecast improvements of high-impact weather and facilitate full use of advanced weather information. The program currently focuses on land falling hurricanes, heavy precipitation, and socio-economic impacts. AFW anticipates leveraging the advances made in these focus areas. AFW is eager to leverage future efforts in the areas of observing and assimilation strategies in data sparse regions and urban forecast issues and opportunities. AFW is already committed to the USWRP-affiliated community development of the WRF model and will continue its involvement during FY 2003. The basic WRF model is

running at AFWA now and initial results are very favorable.

University Partnering for Operational Support (UPOS). AFW continued to collaborate through the UPOS program with JHUAPL, the University of Alaska at Fairbanks Geophysical Institute, and the Army Research Laboratory (ARL). UPOS provides a link between university research and the DoD operational community and is currently focused on near-term forecasts of ground, tropospheric, ionospheric, magnetospheric, and solar weather. The goals of UPOS are to provide an alternate path for rapid transition of the best-applied research ideas to the warfighter and to raise awareness of DoD operational needs within the academic community. The partnership delivers prototype operational products to the AF and Army sponsors. The UPOS Steering Committee, which includes the AF/XOW, meets semiannually to review progress and approve new projects. UPOS includes warfighter exercise support to demonstrate utility of products through web-based, non-operational access as well as collecting direct user feedback for faster updates of the prototype systems. Some examples of UPOS tropospheric weather work include fine-scale polar numerical weather prediction, operational volcanic plume forecasting, and electromagnetic propagation forecast maps generated from MM5 output. Examples of space science work include high frequency radar and communication propagation to predict the area a transmitter can illuminate, forecasting coronal mass ejections, and improving determination of solar events that will cause militarily significant space weather effects on and near Earth.

Air Force Research Laboratory (AFRL). In other space weather research, AFRL programs focus on ionospheric impacts to radio frequency systems, space particle specification

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and forecast, solar disturbance prediction, and neutral density effects on Low Earth Orbit spacecraft. Working closely with the DMSP System Program Office at the Space and Missile Center under a Memorandum of Agreement, AFRL supports the development and upgrading of operational space weather sensors, models, and software products to include space environment sensors on the DMSP spacecraft, state-of-the-art ground-based scintillation detectors, total electron content sensors, DISS, the Solar Observing Optical Network, and the Operationalized Space Environment Network Display suite of web-based products. AFRL also conducts customer-supported R&D for NPOESS, the DMSO, the National Reconnaissance Office, the Ballistic Missile Defense Office, the DoD High Performance Computing Modernization Office, and NASA. This program continues in 2004 to build improvements for future operational implementation.

In addition to the AFRL research portfolio, AFW collaborates with others in the space weather community to develop new techniques, models, and systems for transition to operational applications. These include the Community Coordinated Modeling Center, the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), and the previously mentioned UPOS.

Community Coordinated Modeling Center (CCMC). AFW has been a full member of the consortium that formed the CCMC in 2000, co-chairing the CCMC Steering Committee, and contributing to center efforts since 2001 by providing Defense Research and Engineering Network connectivity and exclusive access to a set of supercomputing nodes at AFWA. The CCMC mission is to provide a computing facility to enable, support, and perform research for the next generation of space weather models, preparing them for transition to operations through the

rapid prototyping centers at both the SEC and AFWA. AFW provided funding for a CCMC replacement capability fielded in FY 2002. Additional information on the center is available at its web site at <http://ccmc.gsfc.nasa.gov/>.

In conclusion, through a continuous process of review and definition, the AF documents its requirements for research aimed ultimately at providing timely, accurate, and relevant weather information to the warfighter today and in the future. In meteorological R&D, AFW is committed to continued development of the WRF model and collaboration with others to the benefit of the warfighter and the nation. Space weather research will continue with a strong program in 2004 both at the AFRL, as well as in leveraged programs such as UPOS, to facilitate expediting needed capabilities to operations, at minimum expense.



**PROGRAM OVERVIEW**

The United States Navy has the unique military requirement to assess meteorological and oceanographic (METOC) impacts on naval, joint, and combined operations. METOC support begins by measuring the battlespace physical environment and culminates with safe, effective weapons systems and sensor employment. The perspective is global, and historically focuses on areas outside of the contiguous 48 states, but the emphasis is on wherever the Fleet goes and includes force protection within the coastal waters of the U.S. Developing METOC forecasts and determining potential effects on weapons system information requires:

- collection of data through tactical and dedicated sensors (including satellites);
- fusion and analysis of atmospheric and oceanographic phenomena; and
- use of meteorological information in tactical decision aids and mission planning systems.

The Chief of Naval Operations, through the Oceanographer of the Navy (CNO (N096)), sponsors operational Navy METOC services and related research and development (R&D). The Navy METOC organization provides meteorological services for Navy and joint forces, meteorological products to the uniformed services and other Government agencies, and oceanographic support to all elements of DoD. The Oceanographer of the Navy sponsors programs in four closely related disciplines to provide worldwide, comprehensive, integrated weather and ocean support - meteorology, oceanography, geospatial information and services, and precise time and astrometry. All are used to protect ships, aircraft, fighting forces, and shore establishments from adverse ocean and weather conditions, and to provide a decisive tactical or strategic

edge by exploiting the physical environment. Dual-hatted as the "Navigator of the Navy", the Oceanographer of the Navy serves as the Chief of Naval Operations' focal point for the development of technical standards for navigation plans, data standards, training, and navigation system certification. He also serves as an advocate and broker for all fleet navigation issues. The Oceanographer of the Navy streamlined his staff's organizational structure to better respond to fleet needs with two proactive divisions. The Requirements and Liaison Division works with the Fleet to establish METOC Requirements and maintains an active "Outreach" Program, both within and outside DoD. They work together with the Programming and Assessment Division who manages R&D, materiel and infrastructure resources. The Oceanographer of the Navy's websites for information are at [www.oceanographer.navy.mil](http://www.oceanographer.navy.mil) and (for navigation information) [www.navigator.navy.mil](http://www.navigator.navy.mil).

Research and development is conducted by warfare centers, laboratories, and systems commands, through sponsorship by the Chief of Naval Research and the Oceanographer of the Navy. To ensure that all research and development supported by the Oceanographer is in direct support of the Naval mission as established by formal Navy doctrine, the Oceanographer recently developed and implemented a comprehensive framework to transition research to operations. The Naval Research Laboratory (NRL) and the Space and Naval Warfare Systems Command (SPAWARSYSCOM) are the primary activities that manage naval research and transition to operations, and are supplemented by various universities, industry partners, and organizations under Navy contract. NRL detachments are collocated with the Fleet Numerical Meteorology and

Oceanography Center in Monterey, California, and with the Naval Oceanographic Office at Stennis Space Center, Mississippi. The SPAWARSYSCOM METOC Systems Program Office (PMW-155) is the Navy's single program manager for METOC system development and acquisition.

**METEOROLOGICAL SERVICES**  
UNITED STATES NAVY

Operational support within the Navy is provided by elements of the Naval Meteorology and Oceanography Command (NAVMETOCOM). Navy METOC activities are involved in worldwide collection of observations ashore, afloat and through remote sensors, and in the assimilation and processing of these observations on a global basis to support analysis and forecasting throughout the world.

The Fleet Numerical Meteorology and Oceanography Center (FLENUM-METOCEN), in Monterey, California, provides global, regional, and tactical observations, analyses, and coupled air-ocean forecasts. Environmental data is acquired through links with DoD and NOAA conventional and remotely sensed data distribution systems. By agreement between Navy and AF, FLENUMMETOCEN is the primary DoD global numerical weather prediction center, running the Navy Operational Global Atmospheric Prediction System (NOGAPS), developed by the Naval Research Laboratory's Marine Meteorology Division, also in Monterey. NOGAPS provides global atmospheric predictions and drives a variety of ocean models, including the global Wave Watch III ocean wave model run at F L E N U M M E T O C C E N (Figure 3-DOD-8).

In near-shore regions, the small-scale interactions between the atmosphere, underlying ocean, and nearby land make it necessary to analyze and



Figure 3-DOD-8. Lightning strike on the horizon illuminates the bow of the USS ABRAHAM LINCOLN (CVN 72) during operations in the Arabian Sea. (U.S. Navy Photo)

predict the battlespace environment with higher resolution and improved physics. In addition to the global product suite, FLENUMMETOCEN is uniquely capable of providing high-resolution coupled air-ocean products on short notice for any location in support of global contingency military and humanitarian operations. The Navy's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) is an operational tactical system featuring data quality control algorithms; nested, non-hydrostatic physics; explicit moisture physics; aerosols; and improved data assimilation. Using lateral boundary conditions provided by NOGAPS, COAMPS provides a high-resolution, re-locatable, meteorological and oceanographic prediction capability to support joint littoral operations. COAMPS is routinely run for Europe, Southwest Asia, Western Pacific, Central America, Western Atlantic, the Continental U.S., and the Eastern Pacific. COAMPS is frequently run in other areas around the world as requirements dictate.

NOGAPS and COAMPS forecast

products are distributed via various communications systems including the Internet, either directly to Fleet customers, or through the Navy regional METOC centers. The regional METOC centers develop value-added products and services tailored to specific operational requirements. COMNAVMETOC recently installed computer systems at all their regional centers to run COAMPS in theater, allowing them to respond to Fleet commanders' requirements in near real-time. As a complement to numerical forecast products, FLENUMMETOCEN provides atmospheric and oceanographic observations, satellite products, data extracts, and data for tactical decision aids. Additionally, FLENUMMETOCEN is the designated National "Core Processing Center" for remotely sensed microwave products under the AF/Navy/NOAA Shared Satellite Processing Agreement. The FLENUMMETOCEN web site for information is [www.fnmoc.navy.mil](http://www.fnmoc.navy.mil).

Since atmospheric conditions are inherently coupled to oceanographic

conditions, the Navy's program in meteorology is closely linked with oceanography, which is the focus of the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi. NAVOCEANO's primary responsibilities include the collection, processing, and distribution of oceanographic, hydrographic, and other geophysical data and products. NAVOCEANO recently began disseminating products from the world's first operational global layered ocean model - NLOM. NAVOCEANO is the Navy's primary processing facility for NOAA polar-orbiting satellite data and is the National "Core Processing Center" for satellite-derived sea-surface temperature measurements, providing the global sea surface temperature data critically important to successfully running NOGAPS and COAMPS. Additionally, NAVOCEANO is a DoD Major Shared Resource Center, enabling creation of the latest research and development models on the most modern scaleable, supercomputing architecture and facilitating transition from R&D to operational use. The NAVOCEANO web site for information is [www.navoceano.navy.mil](http://www.navoceano.navy.mil).

#### Tailored Theater and Regional Support

Theater and regional support are provided to forces ashore and afloat through six regional centers delivering METOC services within their broad areas of responsibility (AORs). These centers tailor services to theater requirements, and manage and prioritize dissemination of numerical products from FLENUMMETOCEN and NAVOCEANO. Special products needed to meet requirements of Joint Force Commanders are also generated by the regional centers. Additionally, the Joint Typhoon Warning Center (JTWC) (operated by Navy and AF) is co-located with the Naval Pacific Meteorology and Oceanography Center in Pearl Harbor, Hawaii. Specific METOC products common to

the regional centers include high winds and seas warnings for the world's oceans; tailored forecast support for Navy, Coast Guard and NOAA ships at sea; and ship routing services for ocean transits (Figure 3-DOD-9).

The Naval Ice Center (NAVICECEN), located in Suitland, Maryland, provides tailored ice forecasts and analyses to DoD. The Navy (through NAVICECEN), NOAA, and the U.S. Coast Guard, jointly operate the National Ice Center (NIC). The NIC provides ice analyses and forecasts for the Arctic and Antarctic regions, coastal U.S. waters, and the Great Lakes to civilian and military activities.

#### Local and Aviation Support

NAVMETOCOM Facilities at Whidbey Island, Washington; Naples, Italy; and Jacksonville and Pensacola, Florida, provide aviation forecast services as well as Fleet Operating Area (OPAREA) and local forecasts and warnings for aircraft, ships, submarines and naval bases and staffs. Additionally, there are 29 NAVMETOCOM detachments worldwide. Though the detachments are primarily situated at Naval Air Stations for aviation safety of flight forecasting, several are located at Naval Stations in support of sea-going units. The detachments provide METOC forecasting and warning services to DoD and allied units within their local and functional areas of responsibility. Detachments and Facilities within the continental U.S. use numerical products from both FLENUMMETOCEN and NOAA's National Centers for Environmental Prediction (NCEP). Overseas Detachments and Facilities use FLENUMMETOCEN numerical weather products, in addition to USAF and foreign products. Additionally, FLENUMMETOCEN provides aircraft routing services for military (primarily Navy) aircraft on demand.

One detachment, at the National Climatic Data Center, Asheville, North

Carolina, coordinates the Navy's climatological program as part of the Federal Climate Complex.

#### On-Scene Support

The Navy's permanent afloat METOC assets are their OA Divisions, embarked aboard aircraft carriers, major amphibious ships and command ships. The OA division's primary objectives are safety of ships, aircraft and embarked personnel, optimum tactical and planning support to on-board warfare commanders, and tailored on-scene products and services for the assigned task force/group and Allied units in joint, combined, or coalition military and humanitarian operations (Figure 3-DOD-10).

Deployable Mobile Environmental Teams (METs) are the primary source of on-scene Navy METOC support for other forces afloat and forces deployed ashore in remote operation areas. These teams provide short-term, on-scene services to DoD activities without organic METOC personnel, other government agencies, and elements of the armed forces of Allied nations during combined exercises or operations.

METOC products and services provided by these METs are tailored to each unit's requirements, and include tactical METOC information and forecasts for operations, weapon and sensor system employment and tactical decision-making, and climatological information for long-range planning.

#### UNITED STATES MARINE CORPS (USMC)

The mission of the Marine Corps METOC Service is to provide meteorological, oceanographic, and space environmental information, products, and services required to support Marine Corps operations and other military operations. The Marine Corps METOC support infrastructure is designed to readily deploy and operate in austere expeditionary environments. It is capable of providing sustained, comprehensive, and relevant METOC support to all elements of a Marine Air Ground Task Force (MAGTF), as well as bases and stations of the supporting establishment.

#### Organization

The Deputy Commandant for Aviation, Headquarters, United States



Figure 3-DOD-9. USS PAUL F. FOSTER (DD 964) turns away in heavy seas after an attempt to replenish fuel underway. (U.S. Navy Photo)

Marine Corps (Code ASL-37) is the cognizant office for Marine Corps METOC support and requirements. The Marine Corps METOC organization consists of two operational chains-of-command, one for supporting establishment METOC units and the other for the Fleet Marine Force (FMF).

Supporting establishment METOC units are located worldwide at Marine Corp Air Stations (MCAS) and Facilities (MCAF). These activities are manned and equipped to provide direct aviation METOC support and services to host and tenant units at nine major air stations in the continental United States, one in Hawaii, and two in Japan.

Within the FMF, Marines deploy and employ as scalable, tailorable, combined-arms teams known as Marine Air Ground Task Forces. There are three sizes of MAGTFs. From smallest to largest, they are: Marine Expeditionary Unit (MEU), Marine Expeditionary Brigade (MEB), and Marine Expeditionary Force (MEF). Additionally, Special Purpose MAGTFs (SPMAGTFs) may be

formed to support operationally unique situations and/or requirements. All MAGTFs, regardless of size, share four organizational elements that vary in size and composition according to the mission: Command Element (CE), Ground Combat Element (GCE), Aviation Combat Element (ACE), and Combat Service Support Element (CSSE).

FMF METOC activities are organized, trained, and equipped to provide tailored support, products, and services to all combat elements of the MAGTF. METOC support is focused towards impacts on Expeditionary Maneuver Warfare (EMW) operations, particularly Operational Maneuver from the Sea (OMFTS). FMF METOC activities are fully interoperable within joint force operations as part of a service or functional component command. When directed to stand-up as part of a Joint Task Force Headquarters (JTF HQ), they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from pre-crisis state to full operational capabili-

ty in a distant theater to provide on-scene support to MAGTF, combined, joint, allied, and coalition operations and other military operations as may be directed (Figure 3-DOD 11).

FMF METOC assets are permanently assigned to Marine Expeditionary Force Headquarters (MEF HQ), Intelligence Battalions, Marine Wing Support Groups (MWSGs), and Marine Wing Support Squadrons (MWSSs). There are three Marine Expeditionary Forces strategically positioned for global response. I MEF, based in southern California and III MEF, forward based in Okinawa, mainland Japan, and Hawaii fall under the control of the Commander, Marine Forces Pacific. II MEF, located at bases in North and South Carolina, falls under the command of the Commander, Marine Forces Atlantic. MEF METOC personnel serve as special staff to the Commanding General (CG) and are under the direction and cognizance of the G-2 (Intelligence) Division.

The three Intelligence Battalions in the Marine Corps are co-located with respective Marine Expeditionary Force Headquarters. These battalions directly support the MEF G-2 and serve as MAGTF intelligence centers during operations. METOC is a vital part of the intelligence estimate and is an essential element that supports the Marine Corps Rapid Response Planning Process. METOC personnel assigned to these commands provide expertise, products, and services that directly support the Intelligence Preparation of the Battlespace (IPB) process by helping intelligence analysts to effectively evaluate, integrate, and synchronize METOC effects for both enemy and friendly courses of action.

Marine Aircraft Wings (MAWs) conduct the complete range of air operations in support of the MEF, to include anti-air warfare, offensive air support, assault support, aerial reconnaissance,



Figure 3-DOD-10. AP-3C Orion of Patrol Squadron Eight (VP-8) is guided by an aircraft director at the Naval Air Station Keflavik, Iceland during one of the frequent winter whiteouts. (U.S. Navy Photo)

electronic warfare, and control of aircraft and missiles. The MAW serves as the principle headquarters for the ACE. Most of the MAGTF's METOC support assets reside within the MAW, specifically at the MWSG and its subordinate MWSSs. These assets are organized, structured, and capable of supporting a variety of MAGTF and ACE-specific operations as defined by the size, scope, and mission requirements. Dedicated METOC support is available for all MAGTF elements from within the MAW/ACE.

#### METOC Support Capabilities

Meteorological Mobile Facility- Replacement (MetMF(R)) - The highest level of METOC support to the MAGTF and ACE-specific operations is the deployment of the MetMF(R). The MetMF(R) provides a METOC support capability similar to that found in garrison METOC facilities, is normally deployed as part of MWSS to a Forward Operating Base (FOB), and is the only realistic option for large-scale MAGTF operations. Once established ashore, the MWSS may detach small METOC support teams with portable ancillary equipment to a forward base in support of ACE units that are separated from the main airbase. This redeployment also provides the MetMF(R) with a forward data collection capability that significantly enhances METOC situational awareness and overall support efforts to the entire MAGTF. With appropriate service personnel augmentation, the MetMF(R) is also capable of serving as host for an in-theater Joint METOC Forecasting Unit (JMFU) during joint operations and exercises.

METOC Support Team (MST). MSTs are task organized and equipped to provide a limited level of METOC support to combat elements other than the ACE (e.g. CE, GCE, and CSSE) and can be assigned to support MEU operations. It is capable of rapidly deploying as part of a first-in level of METOC support response to a crisis



Figure 3-DOD-11 Amphibious Assault Vehicles (AAVs) embark on the beach in preparation to off-load marines as part of an amphibious landing exercise during operations in the Pacific Ocean. (U.S. Navy Photo)

and can be easily integrated into an Air Contingency MAGTF (ACM). Additionally, the MST can be assigned to augment a JMFU during joint operations (Figure 3-DOD 12).

Each MWSS within the MAW is structured and organized to provide one MST that consist of one METOC officer, two forecasters, and two observers. When deployed, the MST will normally be assigned to the G/S-2 (Intelligence) division/section of the supported combat element or MEU. The MST deploys with rugged, ancillary environmental collection and data processing equipment. During operations they organically collect METOC products, data, and information from the nearest deployed MetMF(R), Navy METOC OA Division afloat, host nation or other METOC support organizations and agencies to satisfy METOC information requirements.

#### Specialized METOC Support

The Marine Corps' Chemical Biological Incident Response Force (CBIRF) was established in 1996 as a result of Presidential Decision

Directive (PDD) 39 to manage the consequences of Nuclear, Biological, and Chemical (NBC) materials or weapons used by terrorists. This national level asset is part of the re-activated 4th Marine Expeditionary Brigade - Anti-Terrorism (MEB-AT) located at Indian Head, Maryland. It is comprised of specially trained and equipped Navy, Marine, and civilian personnel who can rapidly be forward deployed and/or respond to a credible threat of a Chemical, Biological, Radiological, Nuclear, or High Yield Explosive (CBRNE) incident in order to assist local, state, or federal agencies and designated Unified Combatant Commanders in the conduct of consequence management operations. Within the S-2 (Intelligence) section, a permanently assigned METOC forecaster provides specialized NBC dispersion forecast products and services that aid mission accomplishment of this organization.

#### METOC Support Doctrine

Marine Corps Warfighting Publication (MCWP) 3-35.7, MAGTF

Meteorological and Oceanographic Support, provides more detailed information about the Marine Corps METOC Service. An electronic copy is available for viewing and downloading from the Marine Corps Combat Development Command (MCCDC), Doctrine Division web site at <https://www.doctrine.quantico.usmc.mil/>.

### MAJOR METOC SYSTEMS

The capability to provide near real-time global, regional, and local METOC services to the Navy and Marine Corps team requires a robust and evolving set of leading edge technological tools. These tools are embodied in the following systems:

P r i m a r y  
O c e a n o g r a p h i c  
P r e d i c t i o n  
S y s t e m  
( P O P S )  
I I  
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( P O P S  
I I  
U ). The POPS II U operates complex computer-based models of the world's ocean and atmosphere, and disseminates METOC forecasts, charts, imagery, and operational data sets to support deployed Navy and DOD forces worldwide. This data is essential to the safety of personnel and to the operational effectiveness of the Navy's operational platforms, sensors, and weapons; including cruise and ballistic missiles, ships, aircraft, radar, and sonar. POPS II U prediction models must provide horizontal resolutions of 1-5 kilometers, in near real-time, for use in on-scene tactical decision aids and systems. Thus, POPS II U provides tailored and timely predictions of

METOC conditions to assist in optimizing the tactical deployment of U. S. sensor and weapon systems.

POPS II U produces and provides critical, classified and unclassified atmospheric and oceanographic guidance to Navy and DOD activities worldwide on a demanding and responsive, 24-hours/7-day schedule. POPS II U is responsible for all FNMOC operations, including the supercomputing, communications (including receipt of tens of thousands of observations and transmission of hundreds of model products), database management, data assimilation and distribution, and systems control/monitoring. It is the engine that runs all of

METOC predictions. The capability to process this type of highly sensitive information in a wartime scenario is unique to POPS II U. POPS II U also produces and disseminates classified and unclassified global/regional atmospheric guidance that is used by:

- Navy for global ocean, regional and tactical ocean/atmosphere/wave/ ice/tropical cyclone models and distributed tactical forecast systems,
- AF for regional atmospheric models, cloud prediction systems, and strategic decision aids as specified via the Navy/AF agreement,
- Joint Forces Command, Defense Threat Reduction Agency and



Figure 3-DOD-12. A U.S. Marine Corps CH-46 helicopter lands on the desert landing strip Rhino, a forward base of operations outside Kandahar, Afghanistan. (U.S. Navy Photo)

the Navy's global/regional/ tactical atmospheric, oceanographic, wave, ice, and tropical cyclone models. POPS II U is a national system that assimilates both classified and unclassified data. Classified observations from the battlespace provide a rich source of data that improves the initial METOC analyses and ultimately the

L a w r e n c e  
L i v e r m o r e  
N a t i o n a l  
L a b o r a t o r y  
f o r  
W e a p o n s  
o f  
M a s s  
D e s t r u c t i o n  
( W M D )  
d e c i s i o n  
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c o n t i n g e n c y  
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- C e n t r a l  
I n t e l l i g e n c e  
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s u p p o r t ,
- P r e s i d e n t i a l  
S u p p o r t  
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p l a n n i n g .

Support to the operating forces is provided principally through six geographically dispersed regional commands via direct connectivity through DoD circuits. The primary source of data to these regional centers is POPS II U. Additionally, thousands of DoD users receive their product support

directly from POPS II U via the creation of web enabled tactical applications.

POPS II U is composed of a number of different high-performance computer systems, including a 128 processor Origin 3800, two 12 processor Origin 3400 file servers, and a 512 processor Origin 3800. POPS II U forms the primary basis of METOC support throughout DoD. This capability includes state-of-the-art decoders, data management systems, quality control algorithms, and data assimilation software for all types of METOC data from all available sensors. These data will support state-of-the-art numerical weather, ocean, chemical/biological dispersion and acoustic models, run in multiple nested fashion from global scale models at resolutions of tens of kilometers to battlegroup/battlefield models at resolutions of a few kilometers. The POPS II U system performance improvement objectives will optimize DoD support in the following specific areas:

- Long and near real-time period METOC support for warfighter planning/decisions
- Aircraft routing services
- Safe and direct ship routing services
- Hurricane, typhoon and tropical storm prediction
- Open ocean and coastal wave prediction
- Precipitation prediction
- Refractivity conditions/ducting range

- Acoustics support
- Ballistic missile targeting support
- Search and rescue
- Chemical/biological/nuclear transport prediction

Distributed Atmospheric Modeling Prediction System (DAMPS). For centuries, military commanders have looked to the weather for tactical advantage. The Navy is currently the nation's only military service that operates a distributed model in support of tactical weather prediction. DAMPS allows users to ingest high-resolution data and on-scene observations into regional and global model information received from the Fleet Numerical



Figure 3-DOD-13. An Aerographer's Mate prepares to launch a weather balloon at sea aboard USS KITTY HAWK (CV 63). (U.S. Navy Photo)

Meteorology and Oceanography Center in Monterey, California. The result is an on-scene weather model that provides accurate weather predictions for an operating area within a 24-hour timeframe.

DAMPS is fielded at all Navy METOC centers worldwide and uses the COAMPS model to develop METOC prediction products out to 48 hours. DAMPS uses real-time weather

data from ship and battle group observations, including parameters such as wind, temperature, cloud, visibility and radar data, and then incorporate this data into its analysis. This analysis can be highly focused on any area of interest.

Tactical Environmental Support System (TESS). The Navy continues migration towards a modular, interoperable suite of systems to ingest, process, fuse, display, and disseminate METOC data. The program consists of four seamless versions known as the Naval Integrated Tactical Environmental Subsystem (NITES) versions I-IV. NITES systems will be fielded through FY 2006. The four NITES versions are:

- NITES I. Provides Navy decision-makers on major combatant ships with METOC assessments and forecasts, and integrates data with sensor and weapon platform parameters for system performance assessments. Theater METOC Centers use NITES I to provide value-added products to fleet units, and the numerical prediction guidance generated by FLENUMMETOCCEN.
- NITES II. Makes METOC data and products available to Navy and Marine Corps activities afloat and ashore via the Global Command and Control System-Maritime (GCCS-M). TESS data and products are used to feed tactical decision aids resident within GCCS-M.

NITES II is the basis for the Joint METOC Segment of the new Global Command and Control System (GCCS) V3.0.

- NITES III. An unclassified forecast, briefing, and display system tailored to Naval METOC shore activities in support of aviation operations.
- NITES IV. A portable system tailored to Mobile Environmental Team (MET) and USMC Meteorological Support Team (MST) METOC requirements.

Tactical Environmental Data Server (TEDS). TEDS is a storage and data management system for meteorological, oceanographic and environmental information whose architecture is built around the Informix relational database management system (RDBMS). It is the central engine in both the Tactical Environmental Support System (TESS) and the Navy Integrated Tactical Environmental System (NITES), providing data access support to the full spectrum of client applications and METOC models. The METCAST automated delivery software is used to facilitate the subscription of new and updated TEDS data, and the continuous on schedule transport of TEDS data to client tactical decision aids, and applications by means of the Internet (Figure 3-DOD-13).

Tactical Environmental Data Services (TEDServices). TEDServices extends TEDS into the era of Net Centric Warfare (NCW), Sea Power-21, FORCEnet, Task Force Web, and the Navy Enterprise Portal (NEP) by means of a new Web Services architecture as described in the Oceanographer of the Navy's (N096) Operational Concept 2002. TEDServices provides a Data Oriented Service (as defined by the Navy Enterprise Application Developers Guide (NEADG)) that supports both the management and the bi-directional transport of meteorological, oceanographic and other environ-

mental information. The TEDS original RDBMS architecture is being replaced with a lightweight, forward deployed, data cache, which offers warfighters, METOC professionals, TDAs/applications and weapon systems immediate access to the Virtual Natural Environment (VNE). The VNE is a 4-dimensional representation of the user-defined battlespace environment. TEDServices' Clients will use a new METOC Mission Rules Based Data Order (MRBDO) process to subscribe to relevant data by mission, platform, TDA/application, parameter or product. The design tenants of TEDServices include: Data Transport (to reduce bi-directional bandwidth use), Data Management (to simplify data ordering and forwarded deployed data administration), Data Representation (to implement a unified Geospatial Coordinate Process), and DoD Joint Interoperability (to support standards defined by the Joint METOC Interoperability Board).

Environmental Satellite Receiver-Processor (AN/SMQ-11 and AN/FMQ-17). These systems are the principal Navy systems to acquire environmental data directly from satellites. There are different equipment configurations for ships (AN/SMQ-11) and shore sites (AN/FMQ-17), and through their interface with NITES variants they provide remotely sensed information to the operator. The AN/FMQ-17 is capable of receiving direct downloads from geostationary and polar orbiting satellites, while the AN/SMQ-11 receives only polar orbiting satellite data directly.

Automated Surface Observing System (ASOS). ASOS, a joint DoD, DoC, and DoT leveraged program, supports aviation and local area observing requirements at Navy and Marine Corps stations worldwide. ASOS helps assimilate field meteorological parameters and facilitates efficient entry of surface aviation observations and synoptic weather reports into

national numerical models. NAVMETOCCOM has certified a number of ASOS units at local and remote USN/USMC airfields for stand-alone use during off-duty hours, when observers are not present to verify the official station observation.

Supplemental Weather Radars (SWR) (AN/FPS-131 and AN/TPS-76). The Navy has Supplemental Weather Radars to provide Doppler weather radar coverage at selected Navy and USMC sites, mostly overseas, outside of NEXRAD coverage.

Meteorological Mobile Facility Replacement (METMF(R)). The METMF(R) is a transportable system that houses meteorological support equipment for the Marine Air Ground Task Force (MAGTF). This 8 x 8 x 20 foot van provides a fully functioning weather office designed to support Marine Corps expeditionary airfield operations for 30 days without resupply. It includes sub-systems for data collection (local, remote and upper air sensors), data processing, satellite data ingest and display, Doppler radar, communications, briefing support, and support for remote forces. The METMF(R) is interoperable with the Marine Corps C4I systems and METOC systems of the other Services via the Global Command and Control System (GCCS).

Operational Products and Services Optimum Track Ship Routing (OTSR), and Optimum Path Aircraft Routing System (OPARS) are advisory services for fleet units. They are based on NOGAPS, COAMPS and wave forecast data, are tailored to the customer, and provide guidance to the forecaster for the safe operation and cost-effective routing of DoD ships and aircraft, just as they have for nearly 30 years. OTSR and OPARS save the operating forces of all services approximately \$57M/year in reduced fuel consumption and personnel costs.

The Navy METCAST/JMV system is a PC-based software package used to

make FLENUMMETOCEN numerical products available to front line DoD users. All standard meteorological and oceanographic fields, synoptic observations and basic DMSP satellite imagery are also available.

MyWxmap ("My Weather Map") is a Web-based service from FNMOC that allows military and civilian users worldwide to access numerical output of selected weather parameters throughout the world. Because of continually emerging Internet technology, a large subset of these products can also be made available to the general public at no additional cost. It will eventually be integrated into various Web portals now under development.

The Navy's capability to provide operational support for homeland security is oriented around its expertise in conducting a Rapid Environmental Assessment (REA) and providing near real-time environmental support based on that assessment for naval forces. The Navy's strengths in characterizing the environment, through observations and modeling, in conjunction with its distributed facilities and effective network for communications and data exchange, contribute effectively toward the national imperative for the best meteorological support to the mission of homeland security. The regional center at Norfolk, Naval Atlantic Meteorology and Oceanography Center (NLMOC), has been designated a WMD/WME Center of Expertise. They are capable of running HPAC or VLSTRACK on a 24-hours/7-days basis to provide dispersion plume support as required by military and civil authorities.

Since 1983, the Naval Regional Meteorology and Oceanography Center, in Norfolk Virginia has provided long-range forecasts in support of Energy Conservation efforts at Naval shore installations in the continental United States. The services are primarily in the form of extended-range (10 day) temperature forecasts provid-

ed to energy managers to assist in optimizing power plant operations. Monthly temperature/degree day outlooks and long-lead (12 month) seasonal and precipitation forecasts are also issued to assist in strategic planning of fuel purchasing and resource allocation. Documented savings from the Energy Conservation Forecast Program exceed \$62 million, with the majority of savings resulting from power plant steam/air conditioning on/off recommendations and energy resource/fuel allocation based on long-lead forecast products. The program has recently added a Pier Load Forecast that is used by four Naval Stations to help predict ship power requirements. Customers include 128 Navy and Marine Corps facilities and commands.

#### **SUPPORTING RESEARCH**

The Navy administers a diverse research and development (R&D) program, ranging from software development to sensor engineering, and processing, display, and distribution devices. Application of R&D activities of other Services and Federal agencies is always considered, and use of existing government and commercial off-the-shelf items is emphasized.

The Navy is a world leader in the field of numerical weather prediction for marine environmental services. Transitioning fundamental scientific research, through additional development, into operational meteorological and oceanographic models is key to a successful numerical prediction program. This ongoing process includes work at universities and the Naval Research Laboratory's Marine Meteorological Division to keep the Navy Operational Global Atmospheric Prediction System (NOGAPS) and the Coupled Oceanographic and Atmospheric Mesoscale Prediction System (COAMPS) at the leading edge of technology. Development is also underway to improve data assimila-

tion, quality control, and management techniques to support these models. The Navy's suite of models also includes phenomena such as waves, tides, ice, tropical cyclone, and biological/aerosol transport. A complete set of numerical modeling "Roadmaps" can be found at [www.cnmoc.navy.mil](http://www.cnmoc.navy.mil).

The Navy R&D program in remote sensing develops techniques to extract tactically significant information in the littoral regions of the world. Sensors aboard existing satellites are exploited to the greatest extent possible and plans are in place to incorporate new capabilities when introduced. Because many satellite-processing algorithms are designed for use with tactical systems, expert or rule-based processes are used where possible to reduce human-intensive interpretation.

ONR and SPAWARSSCOM continue to explore techniques for assimilating environmental data through non-traditional sensors. One such effort is investigating the AEGIS Weapon System's AN/SPY-1 radar and developing the ability to produce NEXRAD-like radar information from ships at sea.

#### **INTERAGENCY COOPERATION**

Navy and AF have long been cooperating in DoD weather support, and these efforts have led to such successes as the Defense Meteorological Satellite Program and the Joint Typhoon Warning Center. Recently, the two services have reinvigorated efforts to increase efficiencies in their METOC programs through greater cooperation, particularly in the area of support to military Command & Control and Intelligence/reconnaissance systems. An initiative under NAVAF-21 (Navy/AF Cooperation in the 21st Century) was the creation of the Joint METOC Interoperability Board (JMIB). Working groups of this board have been developing a road map to build a Four Dimensional Data Cube (4-D Cube), accelerating the

development of common data base segments and APIs, and developing a common mapping tool kit. All of these efforts are designed to ensure consistent, accurate, relevant, and timely information for both automated and human-in-the-loop planning and decision systems.

To maximize efficiency and benefit for Navy and NOAA cooperative activities, an Umbrella Memorandum of Agreement (MOA) between these two agencies was signed in 1993. Both agencies continue to identify new areas of potential cooperation and review existing agreements for conversion into annexes to this MOA. Specific areas include:

- Cooperative efforts in operational numerical modeling, data exchange, and mutual backup between FLENUMMETOCCEN and the National Centers for Environmental Prediction (NCEP).
- Navy/NOAA/Coast Guard operation of the National Ice Center.
- Cooperative efforts between FLENUMMETOCCEN and the Pacific Fisheries Environmental Lab of the National Marine Fisheries Service.
- Air Force Weather Agency (AFWA) / Navy (FLENUMMETOCCEN, NAVOCEANO) / NOAA-NESDIS agreement on shared processing of satellite data.
- Navy/NOAA agreement on ASOS procurement and installation.
- Satellite altimetry data processing.
- Training cooperation through Cooperative Program for Operational Meteorology Education and Training (COMET).

MOAs also exist between the Department of Commerce, Department

of Transportation, and the Department of Defense concerning procurement and operation of NEXRAD. Additionally, Navy is a DoD participant in the development of the DoC/DoD/NASA converged National Polar-orbiting Operational Environmental Satellite System (NPOESS).

NOAA, Navy and AF are also working together to establish a Weather Research and Forecast Model (WRF) National Concept of Operations. WRF provides a collaborative Numerical Weather Prediction (NWP) environment for numerous national agencies and DoD services to pursue opportunities to process atmospheric ensembles for the future.

There are numerous other bilateral agreements involving FLENUMMETOCCEN, NAVOCEANO and the Navy Regional Centers with other DoD activities. These agreements range from weapons of mass destruction hazard dispersion modeling to specific backup capabilities.

#### **NATURAL DISASTER MITIGATION**

Navy METOC plays a vital role in reducing the impact of natural disasters to units both ashore and afloat. Severe weather warnings are issued at Naval facilities by the local NAVMETOCCOM activity when conditions warrant. For ships operating at sea without METOC personnel embarked, tailored enroute weather forecast messages (WEAX) and high winds and seas warnings provide commanding officers with advance notice of heavy weather, and Optimum Track Ship Routing (OTSR) forecasters monitor ship movements and provide heavy weather avoidance recommendations.

Tropical cyclones and even severe winter storms provide even greater challenges, as ships cannot generally "ride out" storms in port without sustaining damage. Similarly, once they get underway (or "sortie") ships must steer well clear of the highest winds and seas, to avoid personnel injuries and damage and ensure their stability limits are not exceeded. Storms of little consequence to the general public - those that remain well out at sea - are still of great concern to the Navy. Because of the need to sortie ahead of tropical cyclones, the Navy must make decisions 3 to 5 days in advance of potentially dangerous weather. Sortie decisions are extraordinarily difficult to make because of their high cost and impact on personnel and operations. In making these decisions, Fleet commanders must strike a balance between the risks of staying import versus the cost and potential for damage at sea. Additionally, naval exercises and ship transits are often placed at risk by multiple tropical cyclone events, which can make successful evasion extremely difficult.

Forecasts are provided to the fleet commanders and their staffs by the nearest NAVMETOCCOM activity and/or afloat METOC personnel. Within CONUS and adjacent ocean areas, tropical cyclone forecasts in particular are closely coordinated with those of the National Weather Service. Overseas, local tropical cyclone warnings and forecasts are based on guidance provided by the Joint Typhoon Warning Center (JTWC), Pearl Harbor, HI. The Commander of the United States Pacific Command designated FLENUMMETOCCEN as the alternate JTWC.

**ARMY TRANSFORMATION**

Global changes to the strategic environment dictate that the Army significantly alters the way it conducts business (Figure 3-DOD-14). On 12 October 1999, the Secretary of the Army and the Chief of Staff of the Army articulated a vision designed and intended to posture the Army so that it can better meet the demands of the 21st Century: "Soldiers on Point for the Nation...Persuasive in Peace, Invincible in War." This urgent requirement to transform the Army is based upon emerging security challenges in the 21st century as well as the requirement to respond more rapidly across the full spectrum of operations. In support of the National Security Strategy (NSS), the strategic significance of land forces lies in their ability to not only fight and win our nation's wars but also to provide options that shape the global environment to the future benefit of the

United States and its allies. To this end, the Army has developed and is implementing a strategy and plan to guide its transformation.

The Army Vision is about People, Readiness and Transformation. People are the centerpiece of our formations; leadership is our stock in trade. It is imperative that we continue to take care of our quality soldiers, civilians, veterans and their families as we transform our Army. Readiness remains, as it has always been, our top priority. We have a non-negotiable contract with the American people - to fight and win the nation's wars. We must ensure

that at all times, the Army can meet demands of the National Military Strategy (NMS) and requirements specified in the Joint Strategic Capabilities Plan (JSCP). Finally, the Army must transform to become more strategically responsive and dominant at every point on the spectrum of operations.

The vision represents goals for the Army while Transformation and its accompanying Transformation Campaign Plan (TCP) are vehicles for becoming more strategically responsive and dominant. Achieving this

force and the Objective Force, it is necessary to field an Interim Force of up to six brigades, employing Interim Armored Vehicles (IAVs) and currently available commercial off-the-shelf (COTS) equipment. The IAVs selected for the job are the Stryker (Figure 3-DOD-16), which have become the main combat vehicle of the Stryker Brigade Combat Teams (SBCT). The SBCTs are the vanguard of the future Objective Force - they will have full spectrum capability and be available for apportionment to the war fighting Combatant Commanders.

These Brigade Combat Teams will also have the capability to deploy anywhere in the world in 96 hours. This force will not only retain the capability to deploy a combat-capable brigade anywhere in the world in 96 hours, but also a division in 120 hours and five divisions in 30 days. The Objective Force will provide our



Figure 3-DOD-14. The Strategic Environment.

vision requires a complete and radical transformation of the entire Army.

Transformation consists of three major objectives: Initial Force, Interim Force and Objective Force, with three corresponding phases (Figure 3-DOD-15). The first phase of Army Transformation has already begun. During this phase, the Army is fielding an Initial Force of two Brigade Combat Teams at Ft. Lewis, Washington, that will establish and validate an organizational and operational model for future Interim Brigade Combat Teams. To bridge the gap between the capabilities of today's

national leaders with an increased number of options for regional engagement, crisis response and sustained land force operations. The Objective Force is designed and built around a Future Combat System (FCS) that will incorporate state of the art technologies and capabilities into a multi-mission combat system. The Army has significantly increased spending in science and technology in order to develop the operational capabilities of the FCS and the overall force. Throughout the period of Transformation, readiness remains our top priority - the Legacy Force provides this capability.

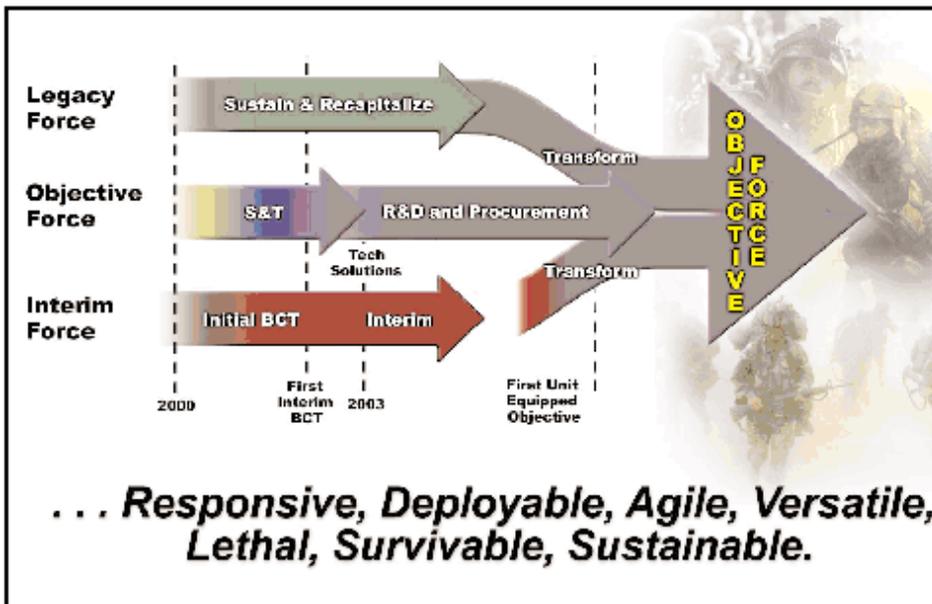


Figure 3-DOD-15. United States Army Transformation.

The Army must fulfill its non-negotiable contract with the American people-to fight and win the Nation's wars. Therefore, the Army must sustain and re-capitalize its Legacy Force to guarantee maintenance of critical war fighting readiness. To accomplish this, the Army will re-capitalize selected legacy formations in its Active and Reserve Components to enhance key armored and aviation systems as well as enhance light force lethality and survivability.

These changes to the Army force structure dictate changes in both weather support requirements and the way weather is provided to the new Brigade Combat Teams. Weather teams will be smaller in size and rely more heavily on "reach back" capabilities to obtain pertinent meteorological data. To that end, the Air Force is working with the Army to optimize the type and level of weather support that will be provided to the new brigades, while still maintaining appropriate support to the legacy force during transformation.

#### OPERATIONAL EQUIPMENT AND SUPPORT MISSIONS

U.S. Army weather support is a mix of Army and USAF personnel and equipment under Law and according to

Army-Air Force agreement. Army Regulation (AR) 115-10/Air Force Joint Instruction (AFJI) 15-157, Weather Support for the U.S. Army, 30 June 1996, describes the Service responsibilities and those of Major Army Commands (MACOMs) within the Army providing weather support. The U.S. Army provides direct weather support to two Army missions: upper air observations for Field Artillery fire support, and limited surface weather observations to support Army weapon systems forward of

Division tactical operations centers (Figure 3-DOD-17). AF Major Commands (MAJCOMs) provide operational weather services to war fighting MACOMs in combat, contingencies, and peacetime training. U.S. Army Forces Command (FORSCOM), U.S. Army Europe (USAREUR), U.S. Army Pacific (USARPAC), U.S. Army Special Operations Command (USASOC), Eighth U.S. Army (EUSA), and U.S. Army Training and Doctrine Command (TRADOC) have AF Weather personnel providing daily installation and tactical weather support. Army Artillery Meteorological (ARTYMET) Crews provide direct upper air observation support to artillery units in the same MACOMs. During peacetime training and activation, the Air National Guard (ANG) provides AF operational weather support to the U.S. Army Reserve (USAR) and Army National Guard (ARNG), collectively designated the Reserve Component (RC). In addition, during exercises and contingencies, the ANG may augment the active Army Combat Weather Teams (CWTs).

The Army also provides the operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges, centers,



Figure 3-DOD-16. The Stryker (U.S. Army Photo)

and other research facilities using the Developmental Test Command's (DTC) Meteorological Teams (MET Teams) and U.S. Army Space and Missile Defense Command (SMDC) contractors. DTC operational support is established under Army Test and Evaluation Command. SMDC provides weather support to the Ronald Reagan Ballistic Missile Defense Test Site at Kwajalein Atoll through a Meteorological Environmental Test Support contractor.

The Army provides the tactical field and communications equipment to USAF CWTs for tactical operations. The Integrated Meteorological System (IMETS) is the U.S. Army's tactical weather communication, intelligence, and information system providing digital weather support to the commanders and staffs of tactical units, from Echelons Above Corps (EAC) to aviation battalions. The Project Director for IMETS (PD, IMETS) falls under the direction of the Project Manager, Intelligence and Effects and the oversight of the Program Executive Officer, Command, Control, Communications - Tactical (PEO C3T). The Communications and Electronics Command (CECOM) and Army Research Laboratory (ARL)

provide fielding and technical support to PD, IMETS and to Field Artillery meteorology programs.

ARTYMET Crews are assigned to Artillery units at Division level, to Field Artillery Brigades, and to Separate Brigades with a direct support Artillery Battalion. Army soldiers regularly take tactical upper air observations to support Field Artillery units during tactical training exercises, at permanent Army Artillery Ranges, or during the full range of combat missions. ARTYMET Crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

ARTYMET Crews in the Active Component (AC) and RC sections currently use the Meteorological Measuring Set (MMS), AN/TMQ-41, to take upper air observations during tactical operations. It is a mobile, upper air sounding system mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV). The MMS provides upper air data to the Field Artillery Tactical Data System for use in adjusting artillery fire, to USAF CWTs, and to the Chemical Officer for use in smoke and in Nuclear, Biological and Chemical

(NBC) defense operations. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK develops requirement documents and is the combat and training developer for meteorological equipment used for Field Artillery support.

The Army provides supplemental, limited surface observations when required in tactical situations to support Army operations. When directed by the Intelligence Officer (S2), Intelligence personnel in the forward combat areas take these observations.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff, G-2, is responsible for Army weather support policy. The Office of the Deputy Chief of Staff, G-3, is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements. In addition, the Army Staff created a position for an Intelligence Officer at the Air Force Weather Agency (AFWA) at Offutt AFB, NE, to serve as a consultant to AFWA for Army weather requirements.

Army Operational Support provided by the Air Force

Under AR 115-10/AFJI 15-157, the AF is responsible for providing the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical and garrison active component (AC) and reserve component (RC) support requirements. Army support manpower requirements are sourced from AF active, reserve, and ANG weather units. While direct support of the Field Artillery remains an Army responsibility, and is supported by Army ARTYMET teams, AF CWTs provide supplemental information to artillery crews in contingencies for areas beyond direct ARTYMET observation capabilities. The AF assigns AF weather personnel to the war fighting MACOMs at theater, corps, division, armored cavalry regiments, aviation brigades, separate brigades, and spe-

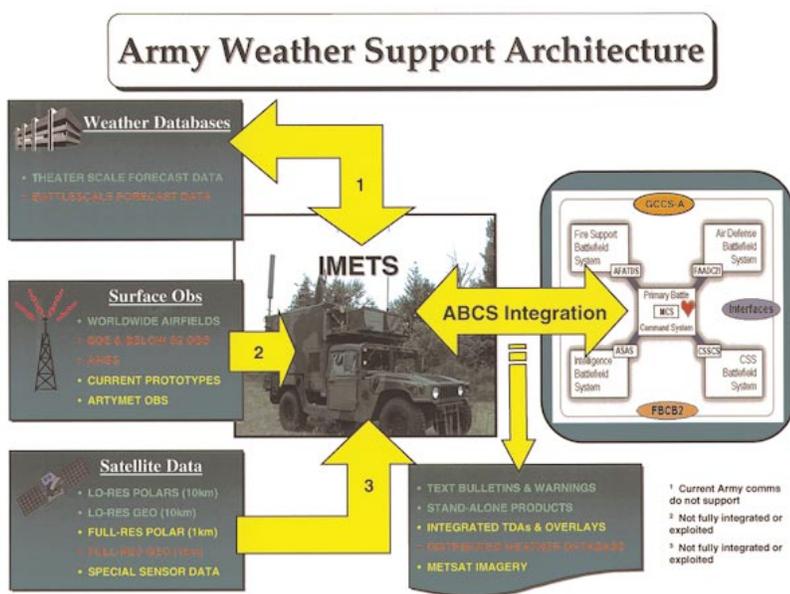


Figure 3-DOD-17. Army Weather Support Architecture.

cial forces groups/ranger regiments to provide direct, on site weather support. AF Operational Weather Squadrons (OWSs) and Combat Weather Teams (CWTs) provide garrison and tactical weather warning, observing, forecasting, special support, and staff weather officer (SWO) services to Combat, Combat Support, and Combat Service Support units throughout the peacetime/war continuum (Figure 3-DOD-18). Peacetime garrison activities include supporting flying operations at Army Airfields and severe weather watch, warning, and advisory services for aircraft and post resource protection. The AF is responsible for installation, operation, and maintenance of standard AF meteorological and observing equipment at Army Airfield Weather Stations. Tactically, the Army is responsible for vehicles, tactical communications, and weather effects criteria. The Army's Integrated

Meteorological System (IMETS) is fielded for these purposes and is operated by AF CWTs. The Army also maintains IMETS hardware and software, with the AF maintaining AF software that performs meteorological functions within IMETS. IMETS uses AF meteorological software, but IMETS is hosted on an Army vehicle, uses Army tactical communications and Army weather effects software. IMETS baseline software is hosted on Army Common Hardware and is Defense Information Infrastructure Common Operating Environment (DIICOE) and Joint Technical Architecture - Army (JTA-A) compliant. The Army provides other tactical equipment to AF CWTs through an Army Table of Organizations and Equipment (TOE).

Eighth U.S. Army

Eighth United States Army (8th U.S. Army) requires and uses Army

resources to conduct two major meteorological services in direct support of Army operations: collecting and disseminating upper air observations for artillery support, and collecting and disseminating limited surface weather observations to support all tactical units and operations.

Two artillery meteorological (ARTYMET) crews with the Second Infantry Division use AN/TMQ-41 Meteorological Measuring Sets to collect upper air observations for direct use by field artillery units. ARTYMET crews also collect routine (usually daily) upper air observations for training; these observations are typically fed into the global weather database.

Additionally, under the Forward Area Limited Observing Program (FALOP), Army personnel use tactical weather kits to collect limited weather observations in data sparse, forward areas. Observations are typically col-



Figure 3-DOD-18. Forecasting wind direction and speed is critical to support paradrop operations, such as this supply drop to elements of the 82nd Airborne Division in Afghanistan's Bahgron Valley. (U.S. Army Photo by SPC Preston Cheeks).

lected by intelligence personnel at brigade and battalion tactical operations centers (TOC) during contingencies or exercises and, in turn, are disseminated to and through AF CWTs supporting Army air, ground, or special operations.

AF weather personnel assigned to the 607th Weather Squadron (607 WS) provide fixed and tactical weather support to 8th U.S. Army units and installations. 607 WS provides garrison and tactical weather observing, advisory, mission forecast, special support, and SWO services during contingency, exercise, and armistice operations. 607 WS units provide direct, on-site support at eight 8th U.S. Army installations and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions. In late FY 2002, 607 WS transferred armistice theater forecast responsibility to the 20th Operational Weather Squadron (20 OWS) at Yokota Air Force Base in Japan. The 8th U.S. Army Combat Weather Teams are now primarily responsible for providing their customers with observations and tailored mission execution forecasts based on 20 OWS overarching forecasts. The lead for METOC support during exercises and contingencies remains with the 607 WS Combined METOC Forecast Unit, in close coordination with 20 OWS. In FY 2004, 607 WS will continue to provide 78 trained weather personnel and will require fixed and tactical weather sensing, data processing, and communications equipment. 8th U.S. Army provides AF weather units needed garrison and tactical communications, tactical vehicles, MTOE and CTA equipment, and operating funds (for expendables, maintenance, etc.) IAW AR 115-10/AFJI 15-157 (June 1996).

#### United States Army In Europe (USAREUR) And Seventh Army

United States Army Europe (USAREUR) and 7th Army require

and use Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations.

7th Weather Squadron (7WS) provides USAREUR/7th Army in-garrison and tactical weather intelligence and support. This includes observing services for in-garrison operations, contingency and exercise operations, SWO services, and specialized support. The United States Air Forces in Europe (USAFE) OWS at Sembach AB, Germany, provides operational-level forecast products for the European Command Area of Responsibility, to include all USAREUR units. Combat weather teams located at V Corps and its aviation assets, 1st Infantry Division and its aviation brigade, 1st Armored Division and its aviation brigade, Southern European Task Force, and 7th Army Training Command, as well as 7WS supporting 7th Army, evaluate and tailor these forecast products to produce mission execution forecasts (Figure 3-DOD-19).

The mission of 7WS and its 9 detachments is to provide weather operations packages to conform to the Army's Transformation initiative. 7WS will match the deploying weather force structure to the mission that USAREUR is called upon to execute. 7WS will utilize "reachback" capabilities to the maximum extent possible to minimize the deployed footprint without compromising weather operations. The Automated Meteorological Information System (AMIS) is the primary in-garrison weather software for receiving forecast graphics and alphanumeric data. Data is received via Very Small Aperture Terminal (VSAT) and hard-wire circuits. The New Tactical Forecast System (NTFS)

is the primary equipment used for deployed locations with data received via Tactical VSAT, NIPRNET and SIPRNET. Units also use the NATO Automated Meteorological Information System (NAMIS) to receive NATO generated weather products. NAMIS software is hosted on a laptop and receives data via VSAT. Satellite imagery (METEOSAT and DMSP) is received via the Small Tactical Terminal (STT), a direct readout system. Seven IMETS have been fielded within USAREUR. The IMETS is geared to interface as a module of the Army Battle Command System to inject weather decision products into the common battle picture for Army commanders. One lighter version of the IMETS (IMETS-L) was fielded in FY 2003 with further fielding expected in USAREUR in FY 2004. This version is designed to mirror the capabilities of the IMETS Vehicle mounted configuration currently fielded, but is much more deployable.

USAREUR provides supporting USAF weather teams with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four ARTYMET sections collect upper air observations for direct use by field artillery units. The Forward Area Limited Observing Program (FALOP) consists of Army personnel taking limited observations at forward areas in the battlespace.

#### U.S. Army Special Operations Command (USASOC)

Weather support to U.S. Army Special Operations Command (USASOC) allows commanders to improve efficiency, effectiveness and safety of operations for USASOC units. USASOC personnel use tactical weather kits to collect limited weather data and provide limited scope meteorological observations from permissive, semi-permissive and uncertain environments in direct support of the Army. Army Special Operations Forces

(SOF) collect weather data at the deployed team level. These observations are passed to operating bases for use by Army commanders and staff, as well as to Air Force Special Operations Command (AFSOC) and ANG weather personnel. AFSOC personnel providing direct support to USASOC units are assigned to the 10th Combat Weather Squadron (10 CWS), OL-A, 320 Special Tactics Squadron (STS) and OL-A 321 STS. ANG personnel providing direct support to USASOC when activated are assigned to the 107th Weather Flight (WF) Michigan ANG, 146th WF Pennsylvania ANG and 181st WF Texas ANG. These weather units provide garrison and tactical support to USASOC units including the 75th Ranger Regiment, 160th Special Operations Aviation Regiment, seven Special Forces Groups, two Psychological Operations Groups and all group and regimental subordinate battalions. Support provided includes climatology and solar/lunar illumination tables and studies, courses of action and mission impacts analysis, weather watch/warning services, mission execution forecasts, flight weather briefings, drop/landing zone forecasts, training to SOF, host nation and indigenous forces on conducting limited observation programs, surface, upper-air and tactical radar observations, strategic weather reconnaissance and Foreign Internal Defense analysis, surveys and training. The 10 CWS also provides staff support to USASOC, U.S. Army Special Forces Command (Airborne) and the U.S. Army John F. Kennedy Special Warfare Center and School.

USASOC plans and expends resources for operational and administrative support to AFSOC, 10th Combat Weather Squadron providing meteorological service support to USASOC components. USASOC provides funding for required training beyond standard special operations weather training, office and deployable

automation systems and connectivity to local networks, dedicated tactical communications systems, operations and maintenance/sustainment to support USASOC requirements, funding for Temporary Duty for USASOC requirements, and organizational clothing and individual equipment. Additionally, USASOC covers expenditures for tactical equipment items such as weapons, NBC equipment, communications, Army developed and procured meteorological equipment, power, vehicles, life support equipment required to accomplish USASOC weather support missions, and for maintenance and supplies for USASOC provided equipment. Seventeen Integrated Meteorological Systems-Light (IMETS-L) have been fielded within USASOC. IMETS-L provides a mobile automated weather data receiving, processing and dissemination system to AF CWTS supporting SOF. IMETS-L also provides digital weather support, real-time tailored weather information, forecasts, and weather effects on friendly and hostile weapons systems to the warfighters. USASOC also provides funding for facilities, office space, office furniture, and real property to house supporting combat weather units, as well as secure storage of required equipment.

#### United States Army Pacific (USARPAC)

United States Army Pacific (USARPAC) uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating surface weather observations to support tactical units and operations.

USARPAC provides supporting USAF units with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operations and maintenance funds.

The Army's IMETS and AF's NTFS have been fielded within USARPAC as the primary meteorological equipment for deployed operations. The IMETS and NTFS reachback for data via Army provided NIPRNET and SIPRNET conduits. Deployed weather teams also use the Small Tactical Terminal (STT) for direct reception of weather satellite imagery.

There are three subordinate commands within USARPAC: United States Army, Hawaii (USARHAW), United States Army, Alaska (USARAK), and United States Army, Japan (USARJ).

The 17th OWS provides USARPAC with garrison and tactical weather warnings, forecasts, special support, and SWO services during contingencies and humanitarian operations. Additional CWTs assigned to U.S. Army Japan (USARJ), U.S. Army Hawaii (USARHAW) (including the 25th ID (-)), and U.S. Army Alaska (USARAK) (including 172 SIB), provide direct, on-site support at 5 USARPAC installations. The CWTs also deploy with their customers providing tailored battlefield observations and forecasts. AF weather reengineering will reduce the requirement for forward deployed weather personnel, and instead leverage IMETS and other recently fielded technology for reach back capability. The 17th OWS will provide regional weather support, allowing the forward deployed CWTs to focus on specific area and target forecasts.

The 20th OWS at Yokota AB, Japan, provides operational-level forecast products for the USARJ AOR, to include all USARJ units. A member of the 20th OWS's staff serves as the USARJ's SWO. In addition, specific resource protection support (i.e. weather advisories, warnings, and watches) is provided for Camp Zama, Japan. An AF CWT assigned to the 374th Operational Support Squadron at Yokota AB is located at Camp Zama.

It provides observational support and produces mission execution forecasts to support aviation operations.

The 11th OWS at Elmendorf AFB, AK, provides operational-level forecast products for the Alaskan Command AOR, to include all USARAK units. The Commander, 11th OWS, serves as the CG, USARAK's SWO. Additionally, the 11th OWS is responsible for Terminal Aerodrome Forecasts for Fort Wainwright, along with resource protection weather support (i.e. weather advisories, warnings, and watches) for Forts Wainwright, Greely, and Richardson. The 11th OWS provides flight weather briefing support, as required, to Army, Army Reserve, and Army National Guard aviation assets in theater. An AF CWT (3 ASOS/WE) is collocated with the 172nd Infantry Brigade (Separate); 172nd Stryker Brigade Combat Team (172 SBCT), at Fort Wainwright; and the aviation assets of 4th Battalion, 123d Aviation Regiment. 3rd ASOS/WE provides weather support for both tactical and garrison operations, observes the atmosphere and evaluates, then tailors, forecast products to produce Mission Execution Forecasts and staff briefings. After the SBCT conversion, 172 SBCT will include tactical unmanned aerial vehicles (T-UAVs), whose operators will also receive their weather support from the 3rd ASOS/WE. The Alaska Army National Guard operates the airfield at Fort Richardson.

#### United States Army Forces Command (FORSCOM)

Weather support to the U.S. Army Forces Command (FORSCOM) is diverse and demanding. FORSCOM, the Army's largest major command, requires and uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather



Figure 3-DOD-19. Accurate weather forecasting for the onset and duration of events such as dust and sand is important for the Army's day-to-day operations. (U.S. Army Photo by Pfc James Matise)

observations to support all tactical units and operations. FORSCOM consists of more than 735,000 AC and RC soldiers. These soldiers account for more than 80 percent of the Army's combat power. FORSCOM trains, mobilizes, deploys, and sustains combat ready forces capable of responding rapidly to crises worldwide. The AC of FORSCOM has nearly 200,000 soldiers. Third U.S. Army is the Army component of U.S. Central Command (USCENTCOM), which is the joint command responsible for Southwest Asia (SWA), the Persian Gulf, and the Horn of Africa. FORSCOM also commands three Army Corps: I Corps at Fort Lewis, Washington, III Corps at Fort Hood, Texas, and XVIII Airborne Corps at Fort Bragg, North Carolina. Together they include six divisions, three armored cavalry regiments, five separate brigades, and a range of other corps combat, combat support, and combat service support units. The two Continental U.S. Armies (CONUSAs), First U.S. Army and Fifth U.S. Army, are responsible for training, mobiliza-

tion, and deployment support to Reserve Component units in FORSCOM.

A major subordinate command to FORSCOM, the U.S. Army Reserve Command (USARC), commands all U.S. Army Reserve units in the continental United States except those assigned to Special Operations Command. FORSCOM's Army Reserve strength stands at approximately 190,000 soldiers. USARC units are part of the Federal force and make their primary contribution to FORSCOM combat power in combat support and combat service support specialties such as medical, civil affairs, transportation, maintenance and supply.

The Army National Guard (ARNG) provides FORSCOM a balanced force of eight National Guard combat divisions, 14 enhanced separate brigades, and a variety of both combat support and combat service support units. The current ARNG strength is approximately 347,000 soldiers.

U.S. Army Signal Command also falls under control of FORSCOM and provides all Echelon Above Corps (EAC) tactical, power projection, and strategic signal support to war fighting unified commanders as well as Army component commanders, in both war and peace.

Weather support to FORSCOM's AC units comes from dedicated AF CWTs aligned under three Air Support Operations Groups (ASOGs): 1st ASOG at Fort Lewis, Washington; 3rd ASOG at Fort Hood, Texas; and 18th ASOG at Pope AFB, North Carolina. A weather squadron for each ASOG makes up the Corps' CWT. Each Army division has their own dedicated CWT. These CWTs are aligned under an Air Support Operations Squadron (ASOS) or one of the weather squadrons, at their respective installations. Corps and division CWTs are authorized enough personnel and equipment to support a variety of missions at the various Army echelons. Weather support at each Army echelon is provided according to Army Field Manual 34-81, Air Force Joint Pamphlet 15-127, *Weather Support for Army Tactical Operations*. Currently, there are nearly 350 AF weather authorizations supporting various echelons across FORSCOM. These AF weather personnel provide garrison and tactical weather warning, observing, mission execution forecast, special support, and SWO services during peacetime, combat, contingency, exercise, or armistice operations (Figure 3-DOD-20).

FORSCOM assigned CWTs provide direct, on-site support at ten major installations, including the National Training Center at Fort Irwin, California, the Joint Readiness Training Center at Fort Polk, Louisiana, and at deployed locations.

Support is focused on air, ground, special operations, other combat, and combat support missions.

FORSCOM provides supporting AF CWTs with a Modified Table of Organization and Equipment (MTOE) and operating funds (expendables, maintenance, etc.). Ten ARTYMET sections, comprised of Army weather personnel, collect upper air observations for direct use by field artillery units.

The AF's N-TFS is the primary in-garrison and tactical weather equipment for receiving graphics and alphanumeric data. Data is received via the VSAT, T-VSAT, Non-Secure

and NOAA meteorological satellites. Twenty-seven IMETS, developed by the Army Research Laboratory, have been fielded within FORSCOM. FORSCOM has fielded commercial Automated Weather Observing Systems at Yakima Training Center Washington, Fort Campbell, Kentucky, and Georgetown Bahamas.

#### Training and Doctrine Command (TRADOC) Programs

Headquarters, TRADOC is responsible for development and management of weather training programs, Army and Joint weather support doctrine (concepts and field manuals), and the establishment of requirement documents for Army tactical weather support. Headquarters, TRADOC is the approval authority for Army-AF weather doctrine, Army weather hardware requirements, and weather support policy. Key mission area for the next few years will be to coordinate weather requirements during AF Weather Reengineering and Army Transformation.

The Army's IMETS continues as a state of the art weather forecast system. Plans are currently underway to merge the best features of the IMETS with the best features of the AF's New Tactical Forecast System (NTFS) (used by CWTs supporting deployed USAF missions). The goal is to develop a single objective weather system, common to both services - to come on line in the 2005 time frame.

#### The Schools and Battle Labs

The U.S. Army Intelligence Center and Fort Huachuca (USAIC&FH) is the functional proponent for Army tactical weather support. The USAIC&FH Weather Support Team (WST) advises the CG, USAIC&FH, Army Research Laboratory, and Air Force Weather (AFW) on Army weather support



Figure 3-DOD-20. Weather forecaster MSgt. Ray Perez poses with the 4th Infantry Division Aviation Brigade's IMETS at Baghdad International Airport during Operation Iraqi Freedom. (U.S. Army Photo).

Internet Protocol Router Network, and Secure Internet Protocol Router Network. The Small Tactical Terminal receives Geostationary and polar orbiting satellite weather imagery from the GOES, GMS, METEOSAT, DMSP,

requirements. The WST succeeded in standing up a full-time manager for the IMETS program, by establishing and staffing the TRADOC System Manager-IMETS office.

In addition, the WST monitors weather training to Army Intelligence and AFW personnel supporting the Army. During FY 2003-04 the WST will partner with USAIC&FH's 111th MI Brigade to stand up an improved SWO course. The new course will lengthen from ten days to four weeks, and will be taught eight times each year. The new course goes into deeper detail, teaching combat field skills and broader coverage of tactics, techniques, and procedures to AF weather forecasters going to their first operational Army assignment.

Over the last year, the WST continued to update and expand the weather effects critical threshold value database, which is incorporated into the joint-service Integrated Weather Effects Decision Aid (IWEDA). Finally, they worked with Air Staff Directorate of Weather to update the Operational Requirements Document (ORD) for IMETS.

The AF SWO at the Army's Combined Arms Center (CAC) is the primary overseer of the Tables of Organization and Equipment for CWTs supporting Army operations. The CAC SWO also arranges for and provides environmental data, concepts of operation, and weather support guidance for various programs, projects, and studies conducted by the TRADOC System Manager for Army Battle Command System, the Battle Command Battle Laboratory-Leavenworth, and the TRADOC Analysis Center. Development of weather scripts and climatological packages to support modeling and simulation exercises of the Battle Command Training Program (BCTP), the Command and General Staff College (CGSC) and the National Simulation Center at Fort Leavenworth

is another key CAC SWO task.

The U.S. Army Field Artillery School (USAFAS), Fort Sill, Oklahoma, is the proponent for upper air meteorological support to the Army. Artillery meteorological crews, AC and RC, currently use the AN/TMQ-50 to measure surface weather parameters, and the AN/TMQ-41 Meteorological Measuring Set (MMS) to take upper air observations. The MMS provides weather data to the Field Artillery Tactical Data System for ballistic calculations; to AF CWTs for weather forecasting; and to the Chemical Officer for obscurant deployment, and Nuclear, Biological, Chemical (NBC) defense operations. TRADOC will work with USAFAS to ensure that surface and upper air observations are sent back to weather centrals where they can be ingested into mesoscale meteorological models. Over the next few years, the MMS will be replaced by an atmospheric sounder system (MMS-P). The sounder can take upper air observations more rapidly and accurately and preclude the logistical burden of helium/hydrogen balloon-based systems.

The Engineer School (USAES), Fort Leonard-Wood, Missouri coordinates weather support requirements for Terrain Analysis and Topographic Engineering. USAES develops methods of measuring and forecasting state of the ground for trafficability assessments using input weather data fields. Their mission also includes identifying, and documenting requirements to interface meteorological and engineer battlefield systems. They employ an AF NCO instructor at the terrain school at Fort Belvoir to teach weather effects on cross-country mobility and engineer missions. USAES, the Army Military Police School, and the Chemical School, all located at Fort Leonard-Wood, Missouri, do not employ meteorologists.

The Aviation Center at Fort Rucker

incorporates weather instruction and procedures into rotary-wing training programs in their mission areas. The Center has requirements for weather observations and AF forecast support at Cairns Army Airfield, Troy Municipal Airport (MAP), Alabama, and Andalusia MAP, Alabama. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites. During FY 2003-04, Air Combat Command will civilianize most weather support to Army Aviation operations at Fort Rucker and surrounding satellite airfields. Two active duty weather officer positions are allocated to provide support to curriculum, and concept development at the Aviation School.

The weather units at Ft Benning, Fort Knox, Fort Rucker, and Fort Huachuca provide airfield observing and forecast support to their respective Army posts.

During FY 2003-04, as directed by the Air Force Chief of Staff, the weather forecasting and observing functions at several TRADOC posts will be outsourced. This direct conversion impacts a total of 8 civilians and 38 military at 9 locations as shown in Table 3.2.

#### Army National Guard (ARNG) Artillery

The Army National Guard has 48 Meteorological Sections assigned to artillery units at Division level, Field Artillery Brigades, and in Separate Brigades. The ARTYMET sections provide upper air observations at least 39 training days each year supporting artillery live fire during Annual Training and monthly Inactive Duty Training. The ARTYMET sections support an average of 20 live fire training days and annually expend in excess of 100 balloons per section. The ARNG is in the process of modernizing to the Meteorological Measuring

<u>LOCATION</u>	<u>BASE</u>	<u>MILITARY</u>	<u>CIVILIAN</u>	<u>TOTAL</u>
Virginia	Fort Belvoir	5	0	5
Georgia	Fort Benning	7	0	7
Kentucky	Fort Knox	5	0	5
Missouri	Fort Leonard Wood	0	3	3
Oklahoma	Fort Sill	5	0	5
Arizona	Libby Army Airfield	1	3	4
Alabama	Fort Rucker	13	0	13
Alabama	Andalusia	2	0	2
Alabama	Troy Municipal Arprt	0	2	2
TOTAL		38	8	46

Table 3.2 Planned outsourcing of weather positions.

Set (MMS), AN/TMQ-41A.

Army Corps of Engineers Civil Operational Activities

The Corps of Engineers (COE) uses a network of about 10,849 land-based gauges. About 55 percent of the sites collect meteorological data, 35 percent a combination of hydrologic and meteorological data, and 10 percent hydrologic or water quality data. The Corps funds or partially funds 58 percent (6,350) of all the gauges it used. Meteorological gauges commonly measure minimum of precipitation, temperature as a minimum. Most sites also measure hydrological data. All data are used in the regulation of COE dams and other water projects used for flood control, navigation, hydroelectric power, irrigation, water supply, water quality, and recreation. The COE transfers funds to NOAA/National Weather Service (NWS) to collect and maintain precipitation information from 826 of meteorological sites. Similarly, COE transfers funds to the U.S. Geological Survey to maintain precipitation data collection from 460 sites, while the COE maintains the rest. Seventy-five percent of all Corps sites provide real-time via satellite, microwaves, meterbursts, landlines, or radio. Data from COE gauging sites are available to other federal, state and local agencies. The NOAA NWS uses 100 percent of all

Corps data. Most of the data is also used by other agencies.

United States Army Space and Missile Defense Command (USASMDC)

Army Space Command (ARSPACE), an USASMDC component, provides operational space weather support on a limited basis to Army units through its Army Space Support Teams (ARSST), as well as Space Operations Officers (FA40). Limited space weather support is provided to Army warfighters as part of ARSPACE's effort to improve overall space support and situational awareness. Potential space weather effects include disruptions of over the horizon communications, radar interference, space environment induced satellite service disruptions, high flyer radiation hazards and hazard warnings to civil power grids resulting from geomagnetic activity.

Force Development and Integration Center (FDIC), a part of USASMDC, is responsible for articulating space requirements including space weather. In addition, FDIC is responsible for development and execution of the Space Operations Officer's Qualification (SOOQ) Course that is the primary training tool for Space Operations Officers. Currently, the Space Weather portion consists of 3 hours of instruction titled, Impacts of Space Weather and Effects of

Atmospheric Weather. Plans are being worked within FDIC to extend the SOOQ training concept to enlisted Army personnel and the Department of the Army Civilian workforce.

The High Energy Laser Systems Test Facility (HELSTF), a subcommand of USASMDC located on White Sands Missile Range, is designated as the DOD National Test Range for high energy laser test and evaluation. In addition to laser systems test and evaluation, extensive use has been made of on-site laser systems to perform damage and vulnerability testing on laser-hardened materials, missile and aircraft components, and assorted battlefield equipment. The atmospheric sciences/meteorological mission is to support HELSTF activities by providing atmospheric propagation and meteorological measurements, planning, and analysis as required. These capabilities also support the safe storage, handling and use of the toxic laser fuels.

United States Army Kwajalein Atoll (USAKA) is a subcommand of USASMDC, which provides operational support for the Ronald Reagan Ballistic Missile Defense Test Site (RTS). The RTS (Figure 3-DoD-21) meteorological services support contractor performs meteorological support for range activities including missile operations



Figure 3-DOD-21. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll (United States Army photo).

within the atoll, intra-atoll transportation (marine and aircraft), remote island missile launches including Wake Island, and severe tropical weather emergency center operations. Supporting these operations are local surface and upper air observations using five upper air sounding systems (two mobile), one polarimetric-Doppler S-band radar, one Doppler C-band radar, two DMSP/NOAA satellite receivers (one mobile) both having McIDAS display and management systems, one geostationary satellite receiver, and an intra-atoll mesonet with an automatic surface observation system at Roi-Namur airfield. In addition, RTS meteorological support in cooperation with NASA is supporting global climate studies through the Tropical Rainfall Measurements Mission and the follow-on program of Global Precipitation Measurement and a smaller program of monitoring the solar-earth radiation flux for NOAA/ERL.

### **WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDTE)**

Under Army-AF agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) to support Army ground combat missions as specified in AR 115-10/AFJI 15-157. The Corps of Engineers (COE), and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations. The Army Test and Evaluation Command (ATEC) is responsible for operational meteorological support to Army RDT&E.

#### Corps of Engineers (COE)

The Corps of Engineers (COE) is responsible for reviewing all emerging Army systems for environmental

effects, as stated in Army Regulation 70-1. The Topographic Engineering Center (TEC), and the Cold Regions Research and Engineering Laboratory (CRREL), of COE's Engineer Research and Development Center (ERDC), develop TDAs to interpret the impact of weather on terrain to enhance Army operations. TDAs are transitioned to the Digital Topographic Support System (DTSS).

ERDC's Topographic Engineering Center, Fort Belvoir, Virginia, provides basic and applied environmental support to Army R&D programs and coordinates the development of TDAs relating to environmental effects on combat systems, operations, and personnel. This includes the development and integration of environmental effects databases and models that are relevant to military plans, operations and the acquisition communities. TEC also develops models and techniques to assist in the generation of proxy environmental information (climate and terrain) for data sparse areas and the integration of models to enable the spreading of this information spatially over map backgrounds. TEC is also responsible for developing integrated software modules that are designed to be exploited in the synthetic environment arena and for developing techniques to portray natural and induced battlefield environments, thus enhancing computerized battle simulations. TEC also contributes to the development of policies and procedures for the consideration of realistic natural environmental conditions for application in the materiel acquisition process. As preparer and custodian of AR 70-38, TEC provides special climatological studies and

guidance to materiel acquisition activities. TEC also reviews all emerging materiel systems for environmental effects.

Under its military mission, ERDC's Cold Regions Research and Engineering Laboratory, Hanover, NH provides support to Army weapon systems RDTE with climatological studies on the effects of winter environment on Army operations. CRREL conducts basic research in sensor signal interaction with snow, ice, and frozen soil, icing accretion on surfaces and structures, deicing technologies, and cold regions surface-air boundary process. CRREL develops databases and models predicting the state of the terrain supporting tactical decision aids such as mobility analysis and sensor performance. Other programs include weather effects on environmental research for military training lands, winter effects on acoustic sensors, helicopter pre-flight deicing and airborne icing avoidance, and estimating snow-water equivalence for predicting snow melt runoff and potential for flooding.

In a recent CRREL ILIR program success, researchers were able to prove a hypothesis that the clustering of



Figure 3-DOD-22. Ice formation from a clustered supercooled water distribution in the NASA Glenn Research Center Icing Research Tunnel. U.S. Army Photo

cloud water affects ice shape formation on the leading edge of the wing resulting in a greater aerodynamic penalty than ice formed from a constant or Poissonian distribution. Figure 3-DOD-22 shows an ice formation from a clustered supercooled water distribution in the NASA Glenn Research Center Icing Research Tunnel. Wind tunnel and numerical modeling of icing of aircraft aerodynamic surfaces use Poissonian liquid water distributions to produce ice shapes. Measurements in natural clouds demonstrate liquid water values tend to be clustered rather than constant.

#### Army Materiel Command (AMC)

The Army Materiel Command (AMC) is responsible for the design, development, test, and evaluation of equipment to satisfy requirements for meteorological support equipment. AMC provides climatological and meteorological support to RDTE projects involving electro-optics and obscurants. It is also responsible for determining weather effects critical threshold values and environmental sensitivities of battlefield systems. AMC has several subcommands and elements carrying out weather research and development responsibilities.

Within the Army Research Laboratory (ARL), the Army Research Office (ARO) manages the Army's extramural basic research program in the atmospheric sciences and the Battlefield Environment (BE) Division is the lead DOD agency for research and development in the portion of the atmosphere unique to the Army warfighter's battlespace--the planetary boundary layer.

BE's mission is to provide the technology and tools (1) for the Warfighter to know and exploit weather on the battlefield, (2) for the Commander to avoid exposing the Soldier to environmental hazards, (3) for the Materiel Developer to quantify the atmospheric effects and minimize the weather impacts on developmental weapons

systems, and (4) that improve the understanding and the underlying science of atmospheric processes at sufficiently high resolution and fidelity to address the close combat environments that will face the Army's future Objective Force. Within the DOD, BE is the lead agency for multi-service R&D programs in transport and dispersion modeling, boundary layer meteorology over land, and atmospheric effects on boundary layer acoustic and electro-optic propagation. In addition, BE contributes to tri-service goals in the areas of theater data fusion and predictions, modeling of boundary layer processes, and assessing atmospheric effects on military system performance. The BE program is driven by the Army's need for meteorological information at smaller scales than used by the AF, Navy, or civilian community, consistent with resolving the effects of local terrain features such as atmospheric conditions within the urban canyons or under vegetative canopies. The BE program also seeks to address how to generate meteorological data over sensor-sparse geographic regions and how to incorporate environmental information from non-standard meteorological sensors and non-traditional weather intelligence sources in near real-time.

While the AF provides the Army with its basic tactical weather support, the Army is tasked to provide technology to support service unique requirements and systems. Tactical Army weather technology includes the distribution of weather forecasts, quantitative effects on system performance, and overall impacts on weapons and operations to the Battlefield Functional Area analysis systems (intelligence, maneuver, logistics, artillery, air defense, terrain analysis) on the current Army Battle Command System (ABCS). BE research for future products is being tailored to the evolving Army Objective Force and Future Combat System requirements for

weather intelligence for continuous and en-route updates to mission planning and execution. This includes the continuous processing of real time atmospheric sensing data and fusion to update a dynamic knowledge base of battlefield environmental effects. This database will provide continuous joint situation awareness of the atmospheric environment and "on demand" generation of alerts, warnings and meteorological decision aids appropriate to specific units and warfighters at all echelons. This new capability will require development of technologies to assimilate and fuse meteorological information in real time from a variety of local sensors along with standard weather observations and remote sensing. Some key weather intelligence may not be in traditional weather observation formats or acquired using standard meteorological sensors at the standard levels.

BE and the PD-IMETS office are partnering with the Air Force in new programs such as the development of a common Product Tailoring Warfighter Application (PTWA). The Army's IMETS and Air Forces' N-TFS software baselines are to converge and transition into one baseline named PTWA by June 2005. This PTWA baseline combines the AF forecast functions with the Army's Command and Control hooks and weather effects software.

The BE Division within the ARL Computational and Information Sciences Directorate, consists of three Branches and two Centers. These span the two BE Division sites at Adelphi, Maryland, and White Sand Missile Range, New Mexico. The three branches combine basic and applied research programs in the areas of atmospheric aerosols and contaminants, chemical/biological transport and dispersion, planetary boundary layer processes, and atmospheric investigations. The two Centers focus on establishing university and external

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laboratory partnerships and providing technology transition of ARL products for support of Army RDTE on weapons systems and weather information technology for tactical command and control and field artillery systems.

The Atmospheric Effects Branch provides basic research and applies theories, laboratory measurements and field studies to produce innovative models, databases and new techniques that quantify the atmosphere and its effects on electro-optical and acoustic propagation, military systems and operations. This includes R&D to characterize simple and complex battlefield atmosphere obscurants, aerosols, gasses, liquids, particles, and various chemical and biological agents. These significantly reduce military system performance or exhibit signatures that are typically small, complex and difficult to distinguish relative to the natural background environment. A range of acoustic propagation models are developed and verified to treat the propagation of acoustic spectral signatures through the atmosphere, including complex 3-D meteorological profiles, atmospheric scattering, ground impedance, and non-uniform terrain effects. Spectral emission, absorption, extinction, fluorescence, inelastic scattering, changes in polarization, turbulence effects and non-linear propagation are modeled and measured to improve intelligence and understanding through the battlefield atmosphere and to mitigate adverse effects and unwanted signals.

The Boundary Layer Meteorology Branch conducts a research program in the micrometeorological processes and structure of the atmospheric boundary layer. This program focuses on the interaction of the land-air interface with wind fields, turbulence, and fluxes and the modeling of aerosol and chemical-biological transport and dispersion in the tactical environment

including urban domains. A range of numerical weather models is addressed, including hydrostatic, non-hydrostatic and diagnostic gridded meteorological models. These are verified against existing numerical weather prediction models and data.

The Atmospheric Investigations Branch addresses improved methods to measure the atmosphere and its processes, to acquire tactical weather data, perform information assimilation and distribution. It includes exploitation of commercial and military satellite technology. The gridded meteorological databases support Army command and control systems and field artillery. Rule-based tactical decision aids for impacts of weather on military systems, platforms and operations are produced based on validated Army weather requirements. Software products are analyzed, verified and delivered for integration into the Army's IMETS. IMETS is the weather INTEL functional area of the Army Battle Command Systems.

The Atmospheric Boundary Layer Exploitation (ABLE) facilities include one site in a complex littoral region located at Blossom Point, Maryland, and another in the desert arid region located at White Sands Missile Range, New Mexico. These two sites are fully instrumented and capable of providing weather data measurements that are used by all aspects of the Division's research and development program.

The Army Research Office, Research Triangle Park, North Carolina, manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with understanding the dynamical and physical processes of the atmospheric boundary layer at scales of interest to the Army (millimeters to 10's of kilometers) through measurements, simulations, and theoretical considerations. The basic research program is conducted through the peer-reviewed, individual investi-

gator program and occasional special initiatives. The focus of the research is on the atmospheric processes and effects of the atmospheric boundary layer where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding of atmospheric effects on soldiers, materials, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on airflow, and the development of natural obscurations throughout the diurnal cycle. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture of the boundary layer at turbulence time scales. Special funding areas are also managed. The Defense University Research and Instrumentation Program (DURIP) provides funds for instrumentation needed to support ongoing research activities. The Defense Experimental Program to Stimulate Competitive Research (DEPSCoR) participation is a competition restricted to universities in certain states that compete for additional basic research funds. Also basic research under the Small Business Innovative Research Program (SBIR) is managed for selected topics. A primary focus continues on the analysis and understanding of the stable boundary layer. New initiatives include acoustic tomography of the atmospheric surface layer and measurement and analyses of wind fields in an urban area.

The following Communications Electronics Command (CECOM) organizations provide support to developing and fielding weather programs: Logistics Readiness Center (LRC), Research, Development and Engineering Center (RDEC), Software Engineering Center (SEC), and Safety office. The CECOM Logistic

Readiness Center (LRC) is the level II manager of the Meteorological Measuring Set (MMS) program. CECOM RDEC's Intelligence and Information Warfare Directorate provides technical management and support to the Program Manager, Intelligence and Effects and Program Manager, Night Vision/Reconnaissance, Surveillance, and Target Acquisition for the IMETS and the MMS-Profiler. A brief description of each of these programs shows CECOM's involvement.

Meteorological Measuring Set (MMS), AN/TMQ-41. The MMS is an upper air meteorological data collection, processing and dissemination system that provides data to the field artillery and target acquisition users. The system is a non-developmental item (NDI). All active Army units are equipped with the MMS. In FY 1999, MMS production and fielding started and will continue through FY 2003 to modernize the National Guard.

The Meteorological Measuring Set-Profiler (MMS-P) AN/TMQ-52 System. The Meteorological Measurement Set-Profiler (MMS-P) is a major improvement over the MMS. The AN/TMQ-52 design will support the new generation of artillery weapons. The system will include frequent and update meteorological messages that enhances the meteorological

validity over a larger battle space than the current equipment. The MMS-P uses the MM5 mesoscale meteorological model to assimilate data from a variety of sources to provide the best meteorological messages to the user in a timely fashion. The system receives data from ground-based sources, radiosondes, and satellite-based sources, (such as boundary data from communications satellites and, in a future program block improvement, polar orbiting meteorological satellites) through onboard satellite receiving capability. The data affects the operation of the mesoscale meteorological model and for post-processing of the data in order to generate meteorological messages. Finally, an operator interface, in conjunction with the message generation and formatting software, facilitates communication between the MMS-P and all other systems that require interoperability with the MMS-P. Currently in development are four System Design and Development (SDD) models. Development and testing is on schedule for FY 2002 and FY 2003 along with a scheduled production decision for FY 2003 (low rate production).

The Integrated Meteorological System, Vehicle Mounted Configuration (AN/TMQ-40B/C) & Light Configuration (AN/GMQ-36). The IMETS is the weather component

of the Intelligence Electronic Warfare (IEW) sub-element of the Army Battle Command System (ABCS) and is the prime candidate to meet Distributed Common Ground Station (DCGS) and Future Combat System (FCS) weather requirements. The IMETS provides commanders at all echelons with an automated tactical weather system that receives, processes, and disseminates weather observations, forecasts, battlefield visualization, and weather effects decision aids to all Army Tactical Command and Control System (ATCCS) Battlefield Functional Areas (BFAs). IMETS receives weather information from polar-orbiting civilian and defense meteorological satellites; civilian forecast centers, the Air Force Weather Agency, artillery meteorological sections and remote sensors. IMETS processes and collates forecasts, observations, and climatological data to produce timely and accurate weather products tailored to the specific warfighter's needs. Significant weather and environmental support to warfighters are the weather applications such as the automated tactical decision aids and contours client. These graphics display the impact of the weather on current or planned operations for both friendly and enemy forces. They can be displayed over the Common Operational Picture / Common Tactical Picture (COP/CTP),



Figure 3-DOD-23. IMETS Mounted Configuration. U.S. Army Photo.

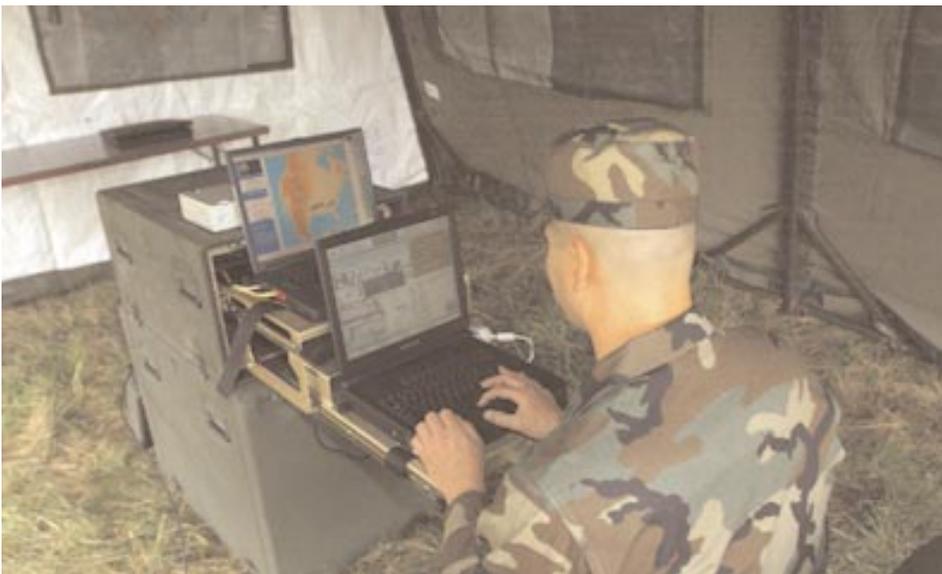


Figure 3-DOD-24. IMETS Light Configuration. U.S. Army Photo

accessed by using a browser, and executed on the users terminal through weather client implementations. The warfighter can effectively employ forces and weapons systems to achieve success in battle.

FY 2004 efforts will focus on three main areas. The Army will refurbish and field 8 AN/TMQ-40B vehicle mounted configurations from the AC to the RC and re-field 8 AN/TMQ-40D's back to the AC. The IMETS Light (Objective) and the IMETS Command Post configuration will undergo a full Developmental and Operational test in 4QFY 2004. The Milestone C decision review to field these systems is scheduled for September 2004 with the first fieldings of both configurations starting in 1QFY 2005.

#### Army Test and Evaluation Command (ATEC)

The Developmental Test Command, a subordinate command of United States Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to eight Army ranges and test sites. Under responsibilities established in AR 115-10/ AFJI 15-157, the DTC meteorological units provide meteorological data collection and analysis, consultation, and weather forecast and warning services to sup-

port Army and other DOD RDT&E activities at the eight Army installations. Funding for the Army RDT&E Meteorology Program under Program Element 665702 has stabilized after several years of decline and is sufficient to maintain the basic meteorological support infrastructure at Army RDT&E ranges and sites. However, instrumentation needed to support unique or test-specific requirements generally must be funded by test sponsors.

The Army RDT&E Meteorology Program has entered into a multi-year working relationship with the National Center for Atmospheric Research (NCAR) to enhance "range scale" (mesoscale to microscale) forecast and analysis technology. The principal product of this relationship is the Four-Dimensional Weather (4DWX) System, which consists of a central data archival/retrieval system for all range and external meteorological and model data, a high-resolution mesoscale meteorological model, and a variety of user-configurable displays. The MM5 mesoscale model is used operationally in both predictive and analysis modes to provide detailed information about the past, current, and forecast structure of the atmosphere over the Army's test ranges. Recent 4DWX enhancements include

the implementation of MM5-based real-time four-dimensional data assimilation (RT-FDDA) capabilities at the major Army test ranges and development of a prototype globally-relocatable mesoscale modeling capability to support Army RDT&E (including DTC Virtual Proving Ground modeling and simulation) at locations other than the Army ranges. Output from mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results.

The Chief of the Meteorology Division at Dugway Proving Ground's West Desert Test Center serves as the Program Manager for Meteorological Support to Army RDT&E. Under Program Element 0605384, the Division's Modeling and Assessment Branch also provides the following specialized services: (1) technical assistance to the DTC operational meteorological teams/branches; (2) atmospheric model verification and validation, including algorithm evaluation and the generation of validation data sets; (3) chemical/biological (CB) threat analysis studies for the Joint Contact Point (Project DO49); and (4) technical assistance to the DoD CB defense modeling community in the development of new CB hazard assessment models. Division employees also serve on various national and international committees addressing issues related to meteorological measurements, atmospheric dispersion modeling, and chemical/biological hazard assessment.

## Army Medical Research and Materiel Command

The U.S. Army Research Institute of Environmental Medicine (USARIEM) conducts basic and applied research on the effects of heat, cold, high terrestrial altitude and nutritional status on the health and performance of individual soldiers and combat crews operating Army systems.

Applied research in thermal physiology and biophysical modeling is directed towards improving soldier performance and minimizing health risks in climatic extremes. The sensitivity of the soldier to local weather parameters (primarily ambient temperature, dew point, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The overall goals of USARIEM weather-related research programs are to develop methods to effectively monitor and, where possible, extend the operational envelope for both training and operational scenarios.

Weather-related research efforts include:

- the development and validation of automated methods to integrate thermal strain prediction models with real-time weather information resources relevant to dismounted infantry operations. Temporal and spatial scales of interest are meters to kilometers and minutes to several days. USARIEM is working with the Army Research Laboratory Battlefield Environment Division to implement thermal models on Personal Digital Assistant (PDA) devices and the Integrated Meteorological System (IMETS).
- the environmental Heat Stress Monitor (HSM), a pocket-sized electronic device, combines the USARIEM heat strain prediction model with a miniaturized sensor suite to measure air temperature, humidity, wind speed, solar radiation, and barometric pressure. This device provides tailored local guid-

ance on optimal work/rest cycle limits, safe work time, and hourly drinking water needs for a wide range of military clothing types and work categories.

- investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with predictive model processes. The effective fusion of these two real-time data streams will enable near term environmental strain and performance status predictions for individual warfighters. Research efforts in this area are intended to address capabilities identified in the Operational Requirements Document (ORD) for the Army's Land Warrior program.
- the availability of ground level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. A Phase II Small Business Innovative Research (SBIR) project to design and build a very small wireless network-capable, expendable, micro-environmental sensing system is underway, and the feasibility of support Army RDT&E (including DTC Virtual Proving Ground modeling and simulation) at locations other than the Army ranges. Output from mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results.

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to measure air temperature, humidity, wind speed, solar radiation, and barometric pressure. This device provides tailored local guidance on optimal work/rest cycle limits, safe work time, and hourly drinking water needs for a wide range of military clothing types and work categories.

As part of the warfighter physiological status-monitoring (WPSM) program, USARIEM is investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with predictive model processes. The effective fusion of these two real-time data streams will enable near term environmental strain and performance status predictions for individual warfighters.

Research efforts in this area are intended to address capabilities identified in the Operational Requirements Document (ORD) for the Army's Land Warrior program.

The availability of ground level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. A Phase II Small Business Innovative Research (SBIR) project to design and build a very small wireless network-capable, expendable, micro-environmental sensing system is underway, and the feasibility of on-body environmental sensors is also being investigated.